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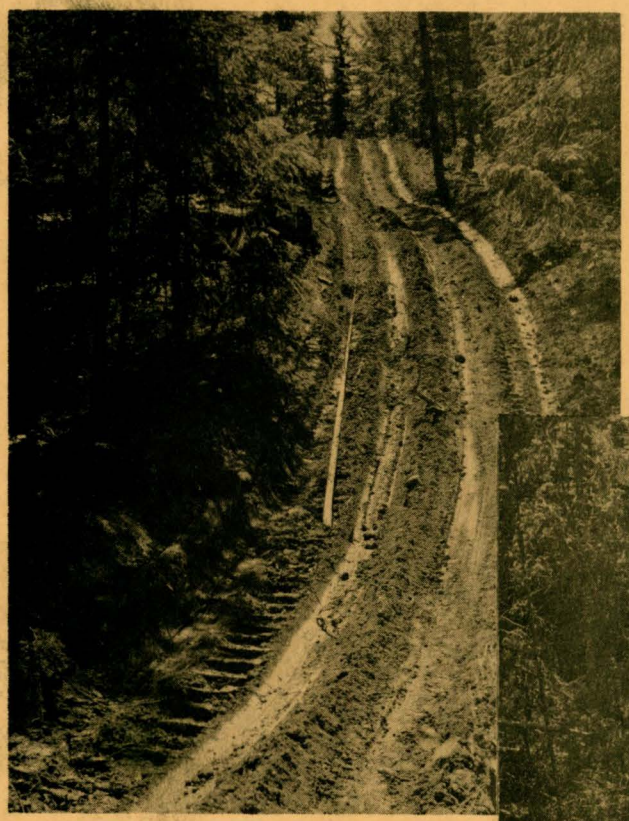
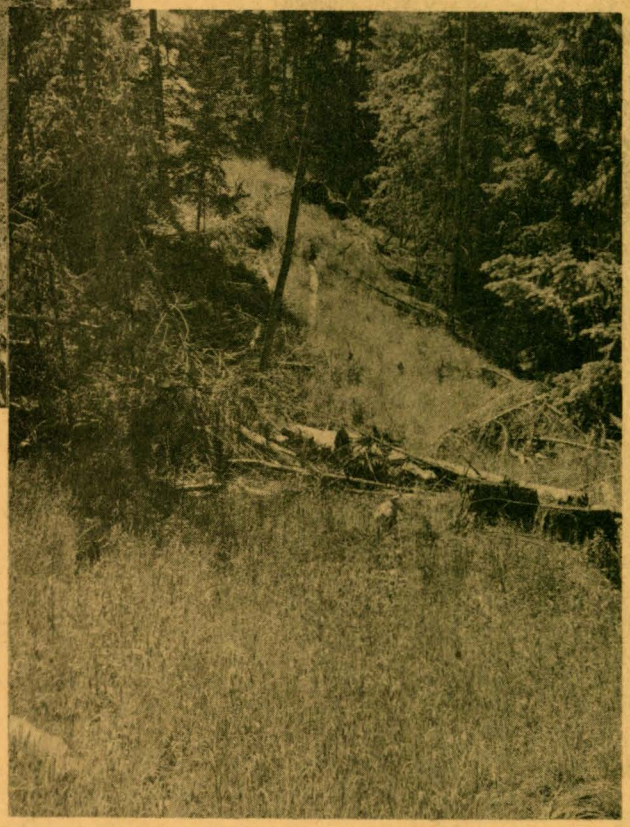


EAST OF THE CASCADES
LOGGING DENUDES MUCH GROUND



RESEEDING DENUDED GROUND TO
PERENNIAL GRASSES STABILIZES SOIL,
AND PROVIDES FORAGE

U.S. DEPARTMENT of AGRICULTURE • FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
J. A. HALL, DIRECTOR

PORTLAND, OREGON MARCH 1949

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EXPERIMENT STATION

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ANNUAL REPORT OF THE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOR THE CALENDAR YEAR 1948

INTRODUCTION

The spring of 1948 will be long remembered as a time of disastrous flood in the Columbia Basin. It will also be remembered as a period when people of the Northwest looked to the mountains and began to wonder about conditions in the high country that might have augmented the flood and the damages resulting from it. There are no certain quantitative answers to the questions posed and to obtain them will require years of effort that has been barely begun. But there are ample results from observation and analogy with other regions that warrant the drawing of certain rather definite conclusions.

The primary cause of the Columbia flood of 1948 was an unusual combination of heavy snow in the upper watersheds, and a late spring, followed by a period of high temperatures and warm rains. It is safe to state that, under any such combination of factors, a flood will result, but its magnitude and destructiveness may be subject to mitigation by downstream engineering works and upstream measures of watershed improvement. The degree of control obtainable from engineering structures is measurable and predictable from reasonably well-known hydrologic data. The role of vegetative cover in slowing up run-off, promoting infiltration, decreasing or preventing erosion and debris movement, is also well-known but less acceptable to engineers because: (1) its quantitative aspects have not been well evaluated on a major watershed scale; (2) vegetative cover has not been a constant in the past and the engineer must deal, as nearly as possible, with certainties. He must build for the maximum probable flood.

Having regard for this point of view, and recognizing the fact that engineering records on the Columbia River system are comparatively recent, it may be logically inquired in what ways the greatest flood of record, 1894, might have been connected with watershed conditions.

Much that affects watershed action had already transpired even before 1894. It must be recalled that until 1905 there was completely unregulated grazing of all public lands, and only since 1934 has there been any regulation of grazing on public domain lands. Furthermore, unregulated grazing went along with unrestrained burning in an attempt to increase grazing, so that vast areas of upland were subjected to repeated burning. In addition, especially in the Rockies and the upper Columbia region, thousands of uncontrolled lightning fires burned millions of acres of watershed repeatedly.

Thus, even before the white man reached the West to increase the toll on watersheds, much of the high country was already doubtless covered with thin vegetation of relatively small value in stream-flow regulation.

A very small beginning has been made in revegetating the range lands, to bring them to something approaching satisfactory cover both for grazing and regulation of water flow and erosion--a huge task of long duration. But above and beyond these lands lie millions of acres of poor cover that are not the result of any action by man.

There is no question but that destructive logging, accompanied by fire, poor road building and logging debris, wreak havoc on the watershed and in the stream channel. But, logging has occurred on only a minor fraction of the watershed and that mostly on the lower, more accessible lands. Knowing what we already know, it is imperative that logging practices be controlled by watershed requirements as operations reach further up the mountains and into the back country. It is easy to visualize what might be the character of a flood arising from conditions similar to those of 1948, if logging practices of the past were carried to the upper limit of commercially accessible timber.

Trees and grass in full cover are the most effective devices for promoting infiltration and preventing erosion. Although prevention of floods in tributaries and main streams is of major importance, maintenance of summer stream flow and ground water levels for irrigation and power are probably of even greater consequence to the Northwest. The function of the forest in slowing snow melt and aiding infiltration; the function of full grass cover in the same way; and the function of both in preventing silt and debris movement into tremendously expensive downstream works, seem to make imperative much more rapid progress in the field of forest and range influences research in this region. There are no satisfactory short cuts by which information can be obtained upon which to base watershed management and improvement programs.

The point of view should be taken that, in the long run, management of watersheds will be of positive nature; not merely the prevention of destructive practices. In a great deal of the Columbia Basin, positive measures of revegetation and improvement of cover may prove to be necessary investments in security and prosperity for the lands below. Irrigation agriculture and electric power are the twin agencies that will eventually make the Columbia support a large population, but both will be at the mercy of the high country.

The 1948 flood was one occurrence. There have been others; there will be more. Agricultural and industrial damages in downstream flooded areas are large but the permanent wealth lost from neglected watersheds probably vastly exceeds them if it is rightly considered as the base upon which the future wealth and well-being of the region depends.

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The leveling of the general business curve in 1948 brought the expected repercussions in the forest products industries. Breaks in lumber prices forced curtailment or cessation of operation of a great many marginal mills, and during the latter part of the year caused drastic curtailment of even some of the very large, well-equipped mills. It appears that distribution channels are rather well supplied and that the transition to a buyer's market is well under way. It is too early to evaluate the effect of these developments on the ability of Pacific Northwest forest industries to continue programs of intensive forest management that have been under way.

From the point of view of research, this Station has tried to make use of the high level of stumpage prices in order to forward its program of applied forest management. The situation may be summed up thus. At the end of the war there was a considerable accumulation of silvicultural knowledge resulting from long years of observation and experimental plot work. There was apparent great need for practical measures of harvesting that could perform two functions; make use of available silvicultural knowledge and provide laboratory set-ups in which to study the effect of various systems of applied management from a silvicultural point of view. Good progress has been made in the last three years along this line.

After a slow start, satisfactory progress was made in the establishment of cooperative experimental forests in western Washington in 1948. With prospects for the establishment of other experimental operations quite bright, it is believed that by the end of 1949 that subregion will be adequately covered with experimental facilities.

It is gratifying to report that a fine experimental forest in Willamette Valley old-growth timber has been established in the Blue River watershed and that initial operations are already well advanced.

The establishment of a new work center for southwest Oregon, with headquarters at Roseburg, offered the opportunity of reactivation of the Port Orford Experimental Forest. A considerable amount of Station effort was directed during the year at evaluation and analysis of the tasks to be performed in the new Siskiyou-Cascade Research Center. There is, in southwest Oregon, a neglected forest empire. Rugged in terrain, unpenetrated by roads, unprotected from fire for generations, the forest is as it grew under uncontrolled, natural forces, aided and abetted in later years by the impact of ill-advised, incendiary burning and clearing for grazing. Yet, in spite of all these adverse forces, the forest has persisted and in immediate years to come will prove to be an increasingly important source of timber products. There is evidence that under adequate protection and intelligent management a great deal of the southwest Oregon territory can produce good crops of sound timber in contrast to the comparatively low yields of highly defective material now on the ground. It will take management of high order.

In addition, much of the territory involved is a tension zone or field of combat between brush and inferior forest species and good

timber. It does not appear that some of the relatively easy silvicultural practices that work in other parts of the region will be broadly applicable over many of the complicated conditions that obtain in southwest Oregon. Indeed, it is anticipated that satisfactory, prompt regeneration after the harvesting of some stands may necessitate planting shortly after cutting. The broken terrain and widely variable climatic conditions will necessitate the development of very flexible management methods.

This territory offers exceptional opportunity for the study of fire ecology and fire control problems in this region, because it seems certain that no influence has been greater than that of fire in creating the situations that exist.

It may be anticipated that with the tightening of lumber markets and consequent decline in stumpage prices, opportunities for such developments as have been successfully executed in the past two years may become temporarily somewhat limited. This will not pose any serious difficulty for some time, because as a result of conditions that have prevailed since the war ample facilities in the way of experimental operations have been developed to keep silviculturists busy for a good many years. However, no opportunity will be neglected for further operations in order to broaden the base of management knowledge.

A small start on watershed problems of the region has been made possible by the assignment of one man to this field. A principal function will be cooperation and liaison with the Army Engineer's Snow Laboratory in the Blue River watershed. This staff member will also participate in all matters having to do with aspects of watershed management.

The range program continues to progress at a steady pace. Excellent results of the reseeding program have already been put into effect in a practical way. The Starkey Experimental Range development program has been forwarded according to plan, and actual range management operations should soon be in full progress. Repair of land damaged by logging in the pine region increasingly demands attention. Skid roads and landings and other heavily disturbed areas are not only lost to grazing use unless seeded promptly to grass; they often constitute active erosion areas that are lost to both trees and grass. Much fine progress is being made in development of satisfactory techniques for handling this problem.

It is hoped that staff additions in 1948 will permit considerably more attention to the general problem of invasion of grazing lands by inferior tree species. An ecological approach to the problem should first provide answers to the question of why this occurs. Practical solutions to the problem should follow.

Increasing needs for intensification of the Forest Survey are created as intensity of forest management progresses, but these needs cannot be met under current financing. Some cooperative effort is in operation and is fairly satisfactory, but not the most efficient method

of doing the job in the long run. It is hoped that this problem may be worked out in the near future.

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Fuller descriptions of individual division programs follow.

FOREST ECONOMICS

Forest Survey

Time spent in preparation and refinement of work plans and training of personnel in previous years commenced to pay dividends during 1948. Approximately 4.5 million acres of forest land was covered by field surveys in southwestern Oregon during the year. Field work was completed in Douglas County (2,851,000 acres of forest land), Josephine County (1,083,000 acres of forest land), and Curry County (978,000 acres of forest land). A small portion of Coos County's forest land was covered and the remainder will be completed next field season.

A considerable part of the area covered in southwestern Oregon was extremely inaccessible and lack of transportation facilities was a costly factor in field operations. Large areas in the Siskiyou Mountains were of questionable commercial character, partly because of inherent low site quality and partly because of a long history of repeated fires. Added to this difficulty was a complex vegetative mantle in this area. A joint field meeting with the Survey staff of the California Station was held there during the summer to coordinate classification of forest land and types that characterize this area and contiguous parts of California.

Anticipating more intensive and exacting requirements for Survey findings, various alternative systems of forest surveys were considered, including the continuous inventory system, and a cost analysis was made of the most promising.

Projection from aerial photos to base maps was completed for Lake, Josephine, and Curry Counties and commenced for Douglas County. One-inch-to-the-mile detailed type maps were drafted and published for Lake and Jackson Counties, Oregon.

Office compilation of type areas and timber volumes was completed for Lake and Jackson Counties. "Saw-Timber Volume Estimates for Oregon and Washington" was prepared and mimeographed. This publication shows a total saw-timber volume of 322 billion board feet, log scale, in Oregon and 217 billion board feet in Washington as of January 1, 1947.

The field work was completed on three cooperative survey projects aggregating about 800,000 acres in Douglas County, Oregon. All projects required production of a type map in more detail than that for regular Forest Survey standards to provide a basis for management plans for

sustained yield units. On one project of 260,000 acres more field volume samples were also required in addition to normal Forest Survey intensity. All expenses beyond those Forest Survey would have expended on regular re-inventory were contributed by cooperators in terms of cash, aerial photography, or manpower. The U. S. Bureau of Land Management was one of the cooperators. The following private companies also cooperated either directly or through consulting firms: Harbor Plywood Corporation, Fir Manufacturing Company, Robert Dollar Lumber Company, and Roseburg Lumber Company.

For information of the Washington Office estimates were made of the physical volume of production and dollar value of all primary forest products (sawlogs, peeler logs, pulpwood, poles, piling, etc.) cut in Oregon and in Washington during the calendar year 1948. Total value of products in Oregon was estimated at 361 million dollars; in Washington it was 169 million dollars.

Financial Aspects

Lumber grade recovery studies. Progress during the year on lumber grade recovery studies consisted of the following: (1) Completed the report of the study carried on at four small second-growth mills in Washington. This report will be printed in an early edition of a local trade journal. (2) A lumber grade recovery study was made at the Fall Creek Lumber Company's portable Swede gang mill. This is part of a second-growth Douglas-fir thinning experiment being carried on in conjunction with the Willamette National Forest. (3) A study which gave the costs and returns of producing lumber from salvaged logs was carried on at the Dwyer Lumber Company's Swede gang mill. This study was part of a detailed appraisal of a relogging operation on the Mt. Hood National Forest. (4) Assistance was furnished the Oregon Forest Products Laboratory with their mill-scale study of defective logs at the Pope and Talbot mill in Oakridge, Oregon. A comprehensive decay study is being carried on and this phase of it was to get data on the ability to determine cull from surface indications on both logs and trees, and to determine if it is economical to saw that type of log.

If time and funds are available it would be desirable if the following work could be carried on during 1949: (1) A lumber grade recovery study of the logs cut from the Henderson Creek experimental sale in a 150-year-old Douglas-fir stand. (2) Information is badly needed on the relative value of high-grade logs cut into veneer or into lumber. The proposed study is to run one batch of "peeler" logs through a plywood plant and a similar group through a sawmill and determine the costs and returns on each operation. (3) Continue with the planned lumber grade recovery studies for the various producing areas in the Douglas-fir region. A few of these studies have been made during the past few years but additional information is needed. The next study is planned for the Coos Bay area. This information is needed by government agencies for appraisal purposes and by the private lumber companies which are moving into this locality.

FOREST UTILIZATION SERVICE

In the forest products industries the need for integrated utilization has been even more pronounced during the past year. Not only is it important that the industries themselves in any utilization center be integrated but, also, that the utilization of forest products be integrated with the products of the forest land supplying the raw material for that manufacturing center. The continued development of southwestern Oregon emphasizes this problem very strongly. This section of Oregon has many stands of timber where the old-growth, virgin timber is intermingled with young, vigorous-growing, second growth. Much of the old growth is defective and the utilization of the cubic volume of wood in these stands is a challenge. The substantial volumes of hardwood--madrone, tanoak, alder, and black oak (for which there is no well-developed market)--magnify the complexity of the problem.

Some progress can be reported in solving this problem. Pulping studies have been instigated and much of the Fomes pini-infected wood has been shown to be suitable as a raw material for pulp. Studies have been made on the utilization of tanoak for veneer and plywood manufacture. The conversion of conky fir to molasses and yeast has been studied. This material, also, has been investigated as a raw material for the production of fiberboard (insulating and hardboard). A start in the direction of evaluating Fomes pini-infected Douglas-fir for nonstructural grades of lumber has been made. In this category would be included sheathing, subflooring, crating, and dunnage. All these investigations need to be extended and coordinated to make a full attack upon this problem.

The importance of expansion of the work of the Forest Utilization Service into more detailed investigation of raw material supplies for new utilization enterprises has been pronounced during the past year. More detailed information is needed on types, quantity, quality, and cost of material available for utilization processes. It is vital to the development of utilization centers to have available information on suitable raw materials and to know that new utilization plants will have a continuing supply of raw material. More adequate coordination of the work of current applied forest management research with the development of utilization plants is necessary. In order to obtain satisfactory forest management, new and improved methods of utilization, especially chemical utilization, for the large quantities of material not suitable for the ordinary products, must be developed.

During the past year the more important fields of activity for the Forest Utilization Service have been:

1. The utilization of slabs, edgings, and other byproducts of the sawmill and logging operations for the production of cut stock.

2. The conversion of wood logs to a wood-sugar solution and the subsequent production of molasses, alcohol, and yeast.

3. The development and coordination of cooperative feeding-test programs for Douglas-fir molasses and yeast at West Coast agricultural experiment stations.

4. Seasoning of lumber, particularly common grades.

5. The expansion of the plywood industry not only into the utilization of lower grades of logs and second-growth Douglas-fir but also, to the inclusion of local hardwoods.

6. The production of insulating and hardboard from material not suitable for use as solid wood.

7. Laminated wood products.

8. The evaluation of the properties of second-growth Douglas-fir, including rapidly grown, as distinguished from the currently cut old-growth Douglas-fir.

9. The development of increased pulp and paper capacity to utilize material developed as byproducts of sawmill and logging operations as well as new species.

Reduction in Waste in Logging Operations

Interest in the utilization of "logging waste" in the woods remained at a high level during the year. Investigations along this line were continued. An example of this was a study on an area on the Mt. Hood National Forest in which relogging operations were undertaken. The area had been a stand of 250-year-old Douglas-fir with an understory of hemlock. The fir overstory had averaged 30,000 board feet per acre and contained very little defect. The residual (waste) material consisted chiefly of the small hemlock understory and of short broken chunks from the fir overstory. Generally, it was sound and averaged about 12,000 board feet per acre.

The study was undertaken to develop (1) the cost of relogging by both high-lead and tractor method of yarding, and (2) to determine the lumber recovery from such logs as could be sawed in a Swedish gang mill. By sorting out the small logs from those being cut in the main band mill, sending them along with the salvaged material to the Swedish gang mill, an increased "through-put" of 10 percent in the main mill was obtained.

This was a cooperative study between the Forest Service (Experiment Station and Regional Office) and the Dwyer Lumber Company, who had logged the area three and one-half years previously. The results were published by the Dwyer Lumber Company in a report presented to the Pacific Logging Congress in September 1949.

The yarded logs were hauled to the mill in preloaded trailers, which permitted the truck to pick up a load with a turn-around time of only ten minutes. The logging cost was found to be $43 per thousand

feet, log scale, including a haul of 47 miles from woods to mill. There was little difference in cost between the high-lead and the tractor methods of yarding.

The sawmill study revealed lumber overrun of 46 percent over the scale for logs 10 inches and under in diameter. Larger logs containing defects--broken ends, etc.--developed an overrun of 53 percent. An average for woods-run relogged material developed an overrun of 40 percent. Based upon the current selling prices of lumber at the time the study was made, a realization of about $5 per thousand board feet of lumber was obtained above the cost of logging and manufacturing green lumber. When the material was dried and surfaced, this amount was raised to $19 per thousand board feet, log scale. The study definitely pointed out that when lumber is sold on a rough green basis, the margin for stumpage, profit, and risk was comparatively small, again emphasizing the need for the production of well-manufactured, finished lumber by sawmills.

An earlier salvage operation carried on immediately after the first operation would be expected to yield even better results. These results show that, in areas of this kind, considerable waste material can pay its way in the manufacture of wood products. Another advantage resulting from this operation was the fact that the salvage so reduced the fire hazard that slash burning generally was unnecessary. The relogging, also, had increased the yield of logs from the area by 25 percent.

In the operation of the Fall Creek Lumber Company in Lane County, Oregon, is found another illustration of salvage from cut-over lands. This Douglas-fir area was logged originally about seven years ago for the commercial timber it contained. Two years ago it was relogged with light mobile equipment to recover the understory hemlock. The hemlock was small in size and was converted into lumber through a Swedish gang mill. Now the area is being relogged for the second time to salvage slicing bolts from the residual large-sized Douglas-fir logs containing a large amount of defect. These logs could not be handled by light equipment during the first relogging.

A two-saw bolter mill produces about 6,000 feet per day of slicing blocks which are moved by truck to a box plant making vegetable containers and box shook. The clear blocks are recovered mainly from the sound portions of conky logs and could find use in the manufacture of battery stock and cut stock as well as veneer for vegetable containers.

Most of the material not suitable for slicing blocks was still of sufficiently high quality to have served as a raw material for a hardboard plant.

A New Log Grade

The systems used in commercially scaling logs are based, primarily, upon the recovery of green boards obtained from the sawmill operation. Logs purchased by pulp mills are currently scaled and graded on the same

basis; that is, on the amount and kind of lumber they would produce. As a result, many logs suitable for pulp operations are left in the woods as culls because they do not show sufficient scale to warrant bringing them out. The pulp industry, however, is more concerned with the cubical content of the wood fiber in the log and this Station has proposed developing a pulp grade of logs in which the scale is based upon the solid wood content. A timber sale on the Wind River Experimental Forest has been made in which pulp logs will be scaled on the basis of the solid wood content rather than on the basis of the lumber which could be produced from them.

Reduction in Waste at Sawmills

A major effort of the Forest Service to reduce the waste in sawmills was directed toward the production of cut stock from slabs, edgings, and the other waste material of the sawmill. From studies at the Forest Products Laboratory it appeared that the container market could be a relatively large consumer of lumber cuttings obtained from such waste. Attempts were made by the Forest Utilization Service to bring together cut stock producers in the region with potential consumers in the Midwest. By the end of the year arrangements were completed for the production of a carload of Douglas-fir crating cleats to be used by a Midwest fabricator of high-grade crates. The cleats produced from Douglas-fir slabs and edgings are straight-grained, clear material and do not need to be highly refined in manufacture. They do need to be seasoned to meet the specific gluing and strength requirements of this crate. The production of this type of material from waste should be a particularly attractive outlet for sawmills cutting smaller-sized trees.

Current operations in the Douglas-fir area are producing broom handles, flooring, and furniture parts, indicating the type of products which can be made from salvaged material.

During the past summer an extensive survey of the quantity, quality, and type of material developed at wood-using plants in Lakeview, Oregon, which could be utilized as raw material for further processing, was made. This investigation was a cooperative project of the industrial committee of the Lakeview Chamber of Commerce and this Station.

Much interest and activity has developed in the past year on the use of sawdust as a mulch. For many years alder sawdust has been in considerable demand. It has been shown recently in a preliminary way that Douglas-fir and hemlock sawdust also are suitable. The Oregon Agricultural Experiment Station now has begun a three-year study on the use of sawdust and other wood wastes as mulch or soil amendments. This project will not be completed before 1951 but should develop much valuable information before that time. The largest outlets for sawdust will be berry growers and nurserymen.

This may help to take up the slack in the demand for sawdust as a domestic fuel. Because of the installation of so many automatic oil burners, sawdust, particularly hemlock, even in the large centers of population, is becoming a drug on the market.

More attention was also drawn to the possible utilization of the defective material in conky Douglas-fir logs. Current sawmill practice utilizes very little of the Fomes pini-infected, decayed portion of Douglas-fir logs (white speck). Douglas-fir in some areas contains such amounts of this that some trees do not have sufficient sound material to warrant logging them. In some areas in southwest Oregon stands are so highly infected that harvesting the timber has been postponed. One of the means for improving the opportunities for harvesting such timber lies in generating a practical utilization of the decayed material found in the tree.

The Forest Service is studying the properties of this infected Douglas-fir to determine to what extent the portion containing "white speck" has sufficient strength to warrant using it. Through cooperation with the West Coast Lumbermen's Association low-grade boards and dimension containing a high percentage of Fomes pini have been shipped to the Forest Products Laboratory at Madison, Wisconsin, for study and for tests on the performance of lumber containing these defects when built into a house.

It is known that the destruction of wood substance by Fomes pini infection is progressive and that in the first stages of infection the strength properties of the wood are but little affected. On the other hand, in the final stages the strength of the wood may be almost entirely lost. Consequently, the utilization of this portion of Douglas-fir wood will require the development of a system of grading to evaluate and segregate those portions which retain sufficient strength properties to make them useful.

Additional studies on the suitability of low-grade Douglas-fir, including Fomes pini-infected material, are under way at the Oregon Forest Products Laboratory at Corvallis, Oregon.

Another factor which is expected to result in decreased sawmill waste is the development of a hydraulic barker for barking sawmill logs. At the Weyerhaeuser Timber Company at Longview, Washington, is the first installation of this kind in the Douglas-fir region. It will give opportunity to demonstrate the extent to which clean bark-free logs entering the sawmill result in a higher utilization of the wood material contained in the log. The Pope and Talbot sawmill at St. Helens, Oregon, has an experimental mechanical log barker in which the bark is removed from the logs while still in the pond.

Reduction in Waste at Plywood Plants

With the trend in the Douglas-fir plywood industry toward the use of lower grade logs in the production of plywood, an even larger amount of unused veneer is developed. To date there is no effective general method of utilizing this waste veneer. Recent developments now permit some mills to chip their green waste veneer and sell it to pulp mills. Some of the plywood trim from the saw is used for cores. Further studies are highly desirable in order to increase the salvage of veneer and plywood

scrap for purposes which will be given a higher return than the present practice of using them for fuel.

Utilization of Western Hardwoods

Studies were continued on the utilization of western hardwood, particularly, tanoak. Currently this species is not utilized at all. The production of tannin from the bark of tanoak has disappeared temporarily at least because of the high cost of collecting the bark. There is currently no utilization of the log in either lumber or veneer form. A shipment of logs was taken to a commercial veneer plant where both sliced and rotary veneer were made from them. Preliminary indications were that tanoak lends itself quite readily to the veneer cutting methods currently in use in the eastern hardwood industry. The marketability of tanoak veneers will be limited to short lengths due to the frequency of knots. Studies will be continued to determine whether--even in short lengths--there will be market opportunities for this veneer.

Seasoning studies of lumber from this species will be carried on at the Oregon Forest Products Laboratory. Successful drying practice could make possible the production of flooring from tanoak. Utilization of bark for tanning, lumber for flooring and similar purposes, and veneer for plywood and furniture would open the way for integrated utilization of the species.

Seasoning of Lumber

The lumber-producing industry in the Pacific Northwest is expanding its kiln-drying capacity. While there may be some loss of kiln capacity due to closing down of old plants, 1948 has seen approximately one million board feet of daily kiln-drying capacity added in the industry. Most of this capacity has been of the conventional forced-draft type of kiln suitable for maintaining high temperature and humidity control. An appreciable amount of new capacity also consists of the lower cost wind-tunnel type of drier which offers drying possibilities for certain lumber items such as common grades which do not require high temperatures.

Most of this increased kiln-drying capacity has been put in at the larger sawmills. Arrangements for seasoning the product of the many small mills have not yet been satisfactorily developed. A limited amount of custom kiln-drying capacity is in operation and this is being used largely for the drying of clear items of lumber. It does not reach the many small mills throughout the region whose production is mostly in the common grades of lumber.

Market conditions continue to favor easier movement for dry lumber. Concentration yards which remanufacture and surface the product of the small mills have not made much progress in equipping themselves with kiln-drying facilities. The need continues to exist, therefore, for further development of low-cost seasoning facilities at both concentration yards and small sawmills. Increased activity has been noted during

the past year in the dry kiln clubs of the region. There are now three such clubs in this area: the West Coast Dry Kiln Club, which covers the Douglas-fir - hemlock area; the Southern Oregon-Northern California Club, which generally covers the pine area in Oregon east of the Cascade Mountains; and the Washington-Idaho-Montana Dry Kiln Club, which, in general, includes the Washington pine area east of the Cascade Mountains. The Forest Utilization Service has been requested to assist the dry kiln clubs in arranging the technical discussions of improved dry-kiln processes and techniques.

Generally speaking, the softwood lumber of this region is being divided into two classes for seasoning: (a) Upper grades, which are used for flooring, interior trim, doors, etc., are dried to moisture contents less than 10 percent. Since siding is obtained from the same grade of material and performs satisfactorily when dried to the same moisture content level, it also is dried with this class of stock. (b) Common grades of lumber, especially in the Douglas-fir region, machine much better if planed at a moisture content of about 18 percent and, therefore, common grades are dried separately from upper grades and to the higher moisture content level. A distinct need, however, is developing in the industry for the drying of certain items to an intermediate moisture content level--12 to 15 percent. Lumber which is to be glued into structural members, arches, trusses, beams, etc., particularly for exterior use, is better suited for the purpose when dried to this intermediate moisture content level. The absence of a drying practice of this level at the mill has compelled the consumer to buy green lumber and do his own seasoning. New markets for other items, possibly cut stock, are likely also to find need for drying to intermediate moisture content levels and it is anticipated that seasoning facilities will be called upon to increase the scope of the drying practice which has been used in the past.

Veneer and Plywood

A number of new veneer and plywood plants came into production during the year or are under construction and will come into production early in 1949. An even greater demand upon the already strained supply of high-grade peeler logs in the Douglas-fir industry has been created. Some new techniques are being worked out in the manufacture of softwood plywood which operate in the direction of utilizing lower grades of logs and yet providing plywood better suited to meet the customer's requirements.

Some mills are introducing the use of high-frequency heating in supplementary gluing operations such as edge gluing of veneer or the gluing-in of patches when repairing exterior plywood. A change was made in the Douglas-fir plywood commercial standards whereby a solid face grade was set up permitting the use of rather large circular plugs to repair open defects such as pitch pockets and knot holes. Such plywood makes economically possible the use of lower grades of veneer. This is an important step when the expanded needs of the industry for raw material are considered.

No appreciable development has been made recently in the application of overlays to softwood plywood but progress is being made in the utilization of trees from younger stands. The Forest Products Laboratory during the year conducted experiments on the cutting of veneer from Douglas-fir logs of second-growth type and studies are under way to evaluate the suitability of such veneers for plywood purposes. The industry already in some cases is producing veneers for interior plies, cutting such veneers from trees 50 to 70 years old and having growth rates as high as four rings to the inch. While the use of fast-grown timber of this type for making veneer and plywood would be exceedingly important in considering timber supplies of the future, considerable research work still needs to be done to adequately evaluate the suitability of such veneer for plywood purposes.

Wood Sugar and Related Products

The War Assets Administration twice has called for bids on the Springfield alcohol plant. Negotiations now are under way with a company of Milwaukee businessmen to again activate this alcohol plant. The price of alcohol has dropped to low levels, but, as far as can be ascertained from the limited experimental operation of this plant, it is still in a competitive position.

The plant itself is the key to large-scale utilization of much waste material in sawmills since the process of producing the wood sugar in this plant would be used in any wood molasses or wood yeast plants built. Before commercial wood molasses or yeast plants can be built, two things must be done: First, semicommercial experimental plants are needed to provide accurate production cost data, design data for the commercial plants, and large quantities of material for exhaustive feeding trials. Second, the suitability of both of these products for livestock and poultry feed must be determined. The first step awaits the reactivation of the Springfield alcohol plant. Apparently, interest from industry still remains high as judged by the number of inquiries on this plant and process which have been received by this Experiment Station.

In the meantime, extensive investigations have been made of the use of wood molasses and wood yeast made from Douglas-fir wood logs. Both Washington State Agricultural Experiment Station and Oregon State Agricultural Experiment Station have extensive feeding programs under way. These include chicks, turkey poults, laying hens, beef and dairy cattle, swine, and sheep. It has been shown in these trials, in a preliminary way, that wood molasses (up to 15-percent level) is suitable as a feed for chicks, turkey poults, swine, and dairy heifers. Preliminary results in using wood molasses as a preservative for grass silage have been very encouraging. Torula yeast is under investigation as a feed for laying hens and chicks. Fundamental studies with small animals are under way on wood molasses and yeast at both institutions. Additional data remain to be collected but progress is being made as rapidly as raw material is available from the small laboratory pilot plants at the Forest Products Laboratory at Madison, Wisconsin.

Alder for Pulp

Red alder, which for years has been considered a weed species in the Pacific Northwest, may come into its own as a pulpwood. The supply of hardwoods in this region is rather limited and considerable quantities of filler-type pulp are needed. The application of the semichemical neutral sulfite method of pulping to alder may solve this need.

Preliminary trials have shown that the material should prove suitable. Extensive wood evaluation studies still need to be made to prove this fact. Of particular interest is the incorporation of this pulp into tissue and toweling papers.

With the continued expansion of the corrugated-board container industry, alder again comes into consideration as a raw material for corrugating medium. Thorough wood evaluation studies need to be made. The third possibility, which has again been explored only in a preliminary manner, is the addition of a high-yield semichemical alder pulp to insulating and hardboard to increase the strength properties of the product where old-growth Douglas-fir has been the main raw material.

Utilization of Sulfite Waste Liquor

The conversion of the calcium-base sulfite pulp mill of the Weyerhaeuser Timber Company at Longview, Washington, to magnesium-base has been completed. The modified plant began operation in the middle of the summer and will serve as a guinea pig for the pulp and paper industry. Because in this case the waste sulfite liquor must be evaporated and burned to recover the magnesium-base, sulphur dioxide is recovered and alleviation of pollution from the pulp mill results.

Certainly, calcium-base sulfite mills, when this plant has operated sufficiently long to be completely proven, will be under renewed pressure by the pollution control commissions of both Oregon and Washington to alleviate the pollution caused by their calcium base liquor.

While no mill in the Pacific Northwest has taken an active interest in the production of yeast from waste sulfite liquor, a number of Wisconsin mills have built a semicommercial plant at Rhinelander, Wisconsin. This plant is now in operation producing a high-grade Torula yeast for feed. Because of the removal of the sugars from the waste liquor, between 50 and 60 percent of the immediate pollution of the waste liquor also is removed.

A new alcohol plant has been constructed at Gatineau in the Province of Quebec by the International Paper Company. The plant was constructed by the Vulcan Copper and Supply Company, who also erected the alcohol plant of the Ontario Paper Company at Thorold, Ontario, and the one of the Puget Sound Pulp and Timber Company at Bellingham, Washington. The plant just now is coming into production. The plant at Bellingham, during the past year, produced about 3 million gallons of industrial alcohol, although the plant was designed for about half this capacity.

Waste sulfite liquor at Bellingham, after recovery of sulphur dioxide and fermentation to industrial alcohol, is evaporated in a small plant to produce a product called "lignosite." About 20 tons per day are produced. It is sold largely to Master Builders, Incorporated, of Cleveland, Ohio, as a base for cement dispersing agents.

Pulp and Paper

The past year has seen renewed activity in the expansion of the pulp and paper capacity of Oregon and Washington. The Weyerhaeuser Timber Company has begun operation of the new 200-ton bleached kraft mill at Longview, Washington. The raw material for this plant is obtained from waste conveyors of the sawmills and from prelogging operations in the woods. By installing a large hydraulic log barker in one of the three Weyerhaeuser sawmills at Longview, the slabs and edgings may be converted to pulp chips without the large amount of labor necessary to put them through hydraulic slab barkers. By building this kraft pulp mill to use material not suitable for the production of lumber, the Weyerhaeuser Timber Company is able to bring in lower grade logs from the woods and increase utilization in the woods.

The pulp division of Weyerhaeuser Timber Company also has under construction a kraft mill at their new utilization center in Springfield, Oregon. This material will produce corrugating medium and liner boards, largely from slabs and edgings of the sawmill. The kraft or sulfate pulping capacity of the Crown Zellerbach Corporation at Camas, Washington, has been doubled during the past year. Most of the raw material for this expanded plant will be wood logs obtained from their salvage operations.

A paper machine has been installed at the Tacoma plant of the St. Regis Paper Company. A number of new pulp mills have been proposed or expansion is planned for existing mills, but nothing definite has developed. It should be noted that the expansion or proposed expansion is mainly in sulfate pulping. Because this process can use resinous woods, it is not selective of wood species.

An extensive research program has been developed by the Forest Products Laboratory to determine the amount of decay which can be tolerated in old-growth Douglas-fir and still produce high-grade kraft or semichemical pulps. The results have been encouraging. Fomes pini which causes conk rot in Douglas-fir, except in its very advanced stages, does not seriously affect the fiber strength of the remaining material. The main cause of loss of strength in Fomes pini-infected wood is mostly from secondary attack by fungi which cause brown rot. They destroy the cellulose and leave the lignin.

Lodgepole Pine - A New Pulpwood

The past year has seen the purchase of an extensive area of lodgepole pine in the Bend, Oregon, area. Approximately 25,000 acres of

lodgepole pine timberland was purchased by the St. Helens Pulp and Paper Company. For a number of months this company has received carload shipments of lodgepole pine from near Chemult, Oregon. This material has come from a combined pulpwood and pole operation. Lodgepole pine kraft pulp is very desirable for blending with and improving the properties of old-growth Douglas-fir kraft pulp. The lodgepole pine produces a pulp with a high-bursting strength with which it is possible to offset the low-bursting strength of the Douglas-fir pulps while still retaining the high tearing value of Douglas-fir.

Log Barkers

At the Camas mill of the Crown Zellerbach Corporation a new, small log hydraulic barker has been installed. This barker is designed for logs up to 20-inches in diameter and 8-feet long. It is patterned after the large barker of the Puget Sound Pulp and Timber Company at Bellingham, Washington. The log is indexed and turned by two rotating rolls fitted with cogs. The water nozzle is suspended over the log and moved forward as the log is being rotated. Actually a lathe-type principle is used except that it is unnecessary to center the log in chucks. It should be emphasized that a saving as high as 20 percent in raw material may be obtained by the use of log barkers and whole log chippers.

The new mechanical barker in the plywood mill of the Weyerhaeuser Timber Company at Longview, Washington, has continued to operate satisfactorily during the past year. This compression-type barker has a small roll to which pressure is applied from a 12-inch diameter air cylinder.

Another type of barker has made its appearance in the past year at the United States Plywood Corporation plants in Seattle and in Mapleton, Oregon. The first installation of this shoe-type head was at the plant of the MacMillan Industries, Ltd., in Vancouver, B. C. The barker head consists of a curved one-inch steel plate 8 x 16 inches. The 8-inch nose of the plate removes the bark and has no sharp cutting edge. The head is held against the log by an air cylinder. In other respects it is conventional in its operation.

The advantage of these types of compression barkers is clean removal of bark without destroying the wood. They are fast and positive.

The hydraulic barker previously mentioned as having been installed in a sawmill of the Weyerhaeuser Timber Company at Longview, Washington, will handle 40-foot logs and is located alongside the log haul into the large log mill. The log is rotated by one set of wheels containing cogs against another set of idlers. This gives the log both a rotating and a forward movement. The two high-pressure water jets developed with the Allis-Chalmers Manufacturing Co. are located beneath the log. The nozzles have an oscillating motion.

The mechanical log barker at St. Helens at the sawmill of the Pope and Talbot Company removes the bark while the log is still in the water. The log is rotated by means of a heavy chain and a mechanical head similar to a conventional mechanical barker used in veneer mills removes the bark as the log rotates.

Certainly, when considering the possibilities of manufacturing pulp or fiberboard chips from slabs and edgings at a sawmill, the barking of logs before the headrig is a decided advantage. All solid wood can be sent directly to a chipper. Besides the credits which are possible because of less handling, higher grade recovery is possible in the sawmill and there is less shut-down for clean-up as a result of bark at various parts in the mill. In addition to these barkers several small log and slab barkers have been installed.

Fiberboard Manufacture

Much interest has developed in the Pacific Northwest in the manufacture of insulating and hardboard. The past year has seen the insulating board plant of the Simpson Logging Company at Shelton, Washington, increase its output from about 70 tons per day to 130 tons, or 300,000 square feet of one-half-inch board per 24 hours, with no substantial modification in the plant. The major raw materials for this plant are byproduct chips produced from slabs and edgings in the sawmill and from green veneer waste in the plywood plant at McCleary. From experimental thinning plots in second-growth Douglas-fir stands, small logs have been used. A sizable quantity of the board output of this plant now is converted to acoustic tile.

Some discussion has taken place on the establishment of one more insulating board plant in the region. All other new plants which have been discussed or proposed are for semi-hardboard or quarter board. The plant of the Stimpson Logging Company, near Forest Grove, Oregon, is about finished and production will be started in the spring. This plant will produce wallboard and use as its raw material chips obtained as a byproduct from the Tillamook Burn logs cut at the sawmill.

The Anacortes Veneer Company at Anacortes, Washington, is constructing a new hardboard plant which will use waste produced from green veneer scrap. The process to be used is the one developed by the Plywood Research Foundation and will be a dry-formed resin-bonded board. Operations will not begin before the fall of 1949.

The new hardboard plant of the Pacific Veneer Division of the Canadian Forest Products, Ltd., at New Westminster, B. C., began operation in May of 1948 and is now producing 40,000 square feet of one-fourth-inch hardboard daily. The process is that developed by the Chapman Manufacturing Company in Corvallis, Oregon. The defiberizing is accomplished with two Asplunds followed by a Bauer used as a refiner. Three percent phenolic resin is added to the stock for improving its strength and dimensional stability. The wet mat is formed by the batch method developed by Ralph Chapman.

At least nine other hardboard plants are in various stages of development. Three of these proposed operations are now in the pilot-plant stage.

Silvicultural Relations

The study of second-growth Douglas-fir at the Forest Products Laboratory has continued. In this investigation the properties of the second-growth Douglas-fir, including rapidly grown material, are being evaluated. This information is needed as we move into a second-growth Douglas-fir economy. These studies are being conducted in cooperation with the Division of Forest Management of this Station. The second-growth permanent plots and experimental forests will be a source of raw material as the investigation is expanded to include the effects of pruning and thinning. Information is needed whereby the growth conditions in the forest can be related to wood quality. It is hoped that this second-growth Douglas-fir study can be expanded in the next year to include a major attack upon the same problem in ponderosa pine.

Charcoal

The charcoal pilot plant at the Oregon Forest Products Laboratory has continued in operation. Five tons of material were prepared for its evaluation as metallurgical and domestic fuel. Two tons were sent East for experimental use in the production of silicon carbide abrasives. In addition, this laboratory has expanded the project to include investigation of the production of activated charcoal primarily for water purification and sugar decolorizing. In doing this they have applied the principle of the fluidized bed developed by the petroleum industry. A new pilot plant has been built.

The pilot plant of the Phillipson Retort Manufacturing Company at Eugene, Oregon, has been tested for its mechanical operation. This plant, which uses a vertical series of horizontal screw conveyors as carbonizing equipment, shows much promise. Development work will be continued.

Cooperation

The Forest Utilization Service has cooperated with a large number of Federal, State, and private agencies during the past year. Some of these are: Oregon Forest Products Laboratory, University of Washington, Washington State College, Institute of Forest Products of the State of Washington, local dry kiln clubs, American Chemical Society, and the Forest Products Research Society.

FOREST MANAGEMENT RESEARCH

Nineteen-hundred and forty-eight was a year of varied activity in Forest Management Research. At the Puget Sound Center development of two new cooperative experimental forests in second-growth Douglas-fir was the principal project. At the Willamette Center, experimental cuttings in thrifty, mature spruce-hemlock at Cascade Head and Douglas-fir at Henderson Creek were executed on commercial scale essentially according to plan, and ground layout was completed for first cuttings in old-growth

Douglas-fir at the new Blue River Experimental Forest, which was established during the year. At Wind River the first post-war experimental cuttings were laid out and negotiations completed for logging by commercial timber sale. In the pine, efforts were directed toward analyzing the problems of mixed stand management and integration of timber and grazing use in the Blue Mountains.

From funds provided by Congress July 1, the new Siskiyou-Cascade Research Center, headquartered at Roseburg, was established and staffed. This has permitted a start on analysis of the perplexing problems encountered in placing under management the complicated and neglected wild forests of southwestern Oregon and the shaping of a research program that will yield useful answers. As first steps in this program, the long dormant Port Orford Cedar Experimental Forest has been reactivated, post-mortem study of past cuttings in the Umpqua and Coos Bay areas was started, and work on selection of experimental tracts representative of the vast interior forests was initiated.

The Portland staff was occupied in supervising and helping with the planning of work at the centers. In addition, they were able to summarize and prepare for publication results of research that have been accumulating from study installations made years ago.

Since 1946, major work of this Division has been directed toward Douglas-fir second-growth management. This emphasis was dictated by the generally poor cutting practices prevailing in young stands and by the accelerating rate of cutting in this age class that occurred during the war and the first few years following. Meanwhile, problems of converting old growth to managed forest have been either neglected or inadequately dealt with. During 1948, however, ground work was laid for expanding substantially Douglas-fir old-growth management research. A start was also made to broaden the pine management work. Most of our total effort is in the field of applied research. Our objective is to provide quickly, good, intermediate answers to the urgent everyday problems pressing forest managers, and in so doing facilitate the installation of fundamental studies which will in time yield final and basic information needed to obtain maximum and continuing benefits from our lands. To achieve a balanced program, work on fundamental studies must be expanded.

A considerable portion of the year's time, both official and unofficial, was invested in training. Staebler spent three months at the statistical seminar in Washington; Silen was on educational leave until July completing work for his M. F. at Yale; in September, Steele departed for academic work at Michigan, and Twerdal for study at Yale. Morris attended the fire control conference in Washington, D. C., and Bullard the forest influences conference at the Southeastern Station. Both Bullard and Tarrant participated in the Forest Service survey of the Columbia River watershed during the spring floods. In October, a group of project and center leaders took part in an interregional management research conference with men from the California Station at the Stanislaus Branch. This permitted program coordination, valuable discussion

of research objectives and methodology, and inspection on the ground of intensive "area management" tests under way at Stanislaus.

Four young foresters joined the staff at the several centers during the year: Kotok and James at the Siskiyou-Cascade, Stein at Wind River, and Shaw at the Puget Sound. We have followed the policy of detailing young recruits to work assignments of several weeks at centers other than their own fairly soon after joining the staff. This has helped the new men to grasp significance of local problems in terms of regional importance and to learn research methodology under several supervisors. Resulting from recruitment activities of the year, in addition to those mentioned above, Lloyd Hayes is joining the Station staff as center leader at Roseburg, James Sowder in pine management studies at Bend, and Owen Cramer in fire studies in Portland early in 1949.

The past year's activities, significant findings, and plans for the year ahead are given in further detail below.

Douglas-Fir Region Old-Growth Management

After more than a century of white settlement, the Douglas-fir region contains about 9 million acres of old-growth timber covering perhaps one-third of the area formerly occupied by comparable growth. There is little likelihood that any significant part of this remaining area will pass into agricultural use. Thus, it is imperative that the harvesting process provide for orderly transition of wild virgin growth to thrifty, managed forests.

Small-plot studies of clear-cutting, partial cutting, fire hazard, regeneration, and growth have been carried on by the Station for more than three decades. The results show that no one method is best for effecting this transition on the variety of stand, site, ground cover, and topographic conditions that occur. Uncontrolled, wide-area clear-cutting that has left in its wake more than 5 million acres of nonstocked and poorly stocked forest land does not qualify as a silvicultural system, but the results of this practice dramatize the need for silvicultural provisions in cutting plans. Likewise, the Station's studies of partial cuttings by tree selection in old-growth Douglas-fir over the past 12 years have, in general, revealed disappointing results. Under pressure of market demands, most of the attempts at partial cutting in old-growth fir have been on a high-grading basis. Of 18 areas studied, less than half showed any net growth in the decade following cutting, and the group as a whole suffered an average net decline in volume of about 1,000 board feet per acre per year, not counting the loss caused by accelerated decay that was found to follow logging injury to the residual stand.

In some stands the results have been better. For example, on a 320-acre partial cutting made at Wind River Experimental Forest in 1944, post-logging mortality amounted to 176 board feet per acre per year the first two years after cutting. Last summer's examination showed that loss had dropped to 104 board feet per acre per year for the second

biennium. Estimated annual growth is considerably above this level. It is significant that: (1) This stand contains several younger age classes of hemlock and silver fir in addition to the overmature Douglas-fir in the main canopy. (2) Silvicultural principles were followed in making the cut, insofar as possible. Less than one-third of the total volume was removed, taking as many of the low-vigor trees as possible at the time. (3) The site appears to be capable of producing good quality Douglas-fir, poorer quality hemlock and silver fir. However, there has been enough Douglas-fir retained in the stand to propagate this species when a future regeneration cut is made. (4) The stand still contains a number of low-quality, low-vigor, and decadent trees--perhaps 20 percent of the remaining volume--that for silvicultural reasons should be removed soon. Harvest of such trees will require (a) utilization facilities capable of operating on low-grade material and (b) efficient logging techniques.

During 1948 a preliminary tree classification for Douglas-fir was devised for use in partial cutting and growth studies. Much work will be required to determine the relative importance of classification factors being tested before a satisfactory system can be developed for routine application.

Following the general failure of wide-area clear-cutting and of so much of the partial cutting, the current trend is to smaller area clear-cuts or "staggered settings." In such a layout the clear-cut patches may range from several acres to 100 acres or so in extent. The most efficient size for any specified set of conditions remains to be determined. This method has a number of advantages over wide-area clear-cutting: (1) More adequate seed source is provided for regeneration; (2) extreme fire hazard resulting from large, continuous areas of logging slash is reduced. It has these apparent advantages over partial cutting: (1) It can be applied on either steep or gentle terrain; (2) it is better adapted to the regeneration of intolerant species; (3) logging costs can usually be reduced.

There are also a number of disadvantages or problems apparent in the application of a staggered setting clear-cutting system: (1) The perimeter of cutting edge is increased for a given area of clear-cutting. This requires skillful location of cutting lines or losses from marginal windfall may be excessive. (2) A greater road mileage must be built and maintained. This is one of the costs of good forestry that cannot be avoided. Far greater skill is required to lay out efficiently a permanent road system that will facilitate good forestry than is required for liquidation cutting.

Preliminary cut-over examinations made during the year show that abundant seed source, such as provided by intensive staggered setting cutting, does not insure regeneration if seedbed conditions are unfavorable. Cutovers were found lost to brush with seed trees nearby. Indication is that brushy areas in the virgin stand must be identified before cutting and special measures taken during logging and slash disposal to permit regeneration of valuable tree species and to prevent reversion to permanent brush.

In cooperation with the national forests, commercial-scale harvest cutting experiments are under way, others are laid out, and still others planned that will test practical on-the-ground methods of solving the above problems. These include: (1) Eleven-million-foot harvest and intermediate harvest cut in mature Douglas-fir at Henderson Creek, started in 1948, to be completed in 1949. (2) Eight-million-foot harvest and intermediate harvest cut in old growth at Wind River laid out and sale negotiated in 1948 for cutting in 1949-50. (3) Ten-million-foot harvest cut in typical Willamette old growth on the new Blue River Experimental Forest laid out in 1948 to be offered for sale early in 1949. Experimental plan for this area calls for the harvest of 10 to 20 million board feet annually for the next decade. (4) Three-million-foot intermediate harvest cut in mature Douglas-fir on the Mt. Hood National Forest laid out in 1948 and to be offered for sale and cutting in 1949. (5) Rehabilitation and regeneration cut on 280-acre tract high-graded for Port Orford white-cedar a decade ago. This cutting will be laid out on Port Orford Cedar Experimental Forest and sale negotiated in 1949. (6) Cooperation with national forests in 1949-50 on post-mortem examination of previous harvest cuttings.

Douglas-Fir Second-Growth Management

The latter part of 1948 witnessed what is probably the first decline in Douglas-fir second-growth cutting that has occurred within a decade. For the common grades of lumber, supply was overtaking market demand. The fact remains, however, that eventually all of our annual timber harvest must come from second-growth forests. Thus, the experiences of 1948 emphasize the fact that our second growth must be managed to produce high-quality material if it is to maintain a place in competitive lumber markets. The objective of second-growth research is to develop methods of doing this at a profit and on a sustained basis.

Methods being tested include the making of stand-improvement thinnings on commercial-scale operations and artificially pruning selected crop trees. Such tests were laid out on Voight Creek Cooperative Experimental Forest in 36-year-old site III stands this year and thinning of the first 18-acre compartment completed. Value of products removed in this improvement cut ranged from $200 to $300 per acre. This intermediate harvest yielded small sawlogs, pulpwood, telephone, power and smelter poles, and car stakes. Obviously, such intensive practices require highly diversified and accessible utilization facilities. Most promising crop trees in the reserve stand were pruned to a height of 19 feet at a cost of 35 cents each, with labor figured at $1.50 per hour. Calculations indicate that the increase in value resulting from growing clear material in the pruned trees will earn 3 percent on the investment and in addition provide a profit several times greater than costs.

Other commercial-scale experimental stand-improvement thinnings were made at Cascade Head in 100-year-old spruce-hemlock and at Fall Creek on the Willamette National Forest in 90-year-old Douglas-fir. Both horses and tractors are being used at Cascade Head, and though final results must

await completion of the operation, it is clear that horse logging does far less damage to the reserve stand and may also be cheaper than tractor skidding for thinning operations. Other tests under different stand, terrain, and market conditions were laid out for improvement thinning by commercial timber sale at Mt. Walker on the Olympic National Forest and at Big Creek on the Snoqualmie.

The McCleary Cooperative Experimental Forest has been surveyed, development plans are under way, and road construction started. First cuttings are planned for 1949. Applications for two other cooperative experimental forests in western Washington were received during the year, one in coastal hemlock, the other in Douglas-fir. It is likely that agreement will be negotiated with the owners early in 1949 for experimental development of at least one of these tracts. Thus, it appears that the need for cooperative study areas will be well served.

This work has had the benefit of guidance and assistance from the Station's Douglas-fir Second-Growth Management Committee, organized in 1947. Since that date the committee members, representing both private and public agencies, have either established and supervised or assisted in getting other experimental second-growth cuttings under way. The preliminary manual "Management of Second-Growth Forests in the Douglas-fir Region," prepared by the committee late in 1947, was distributed during 1948 as a Station multilith. Although distribution was limited to specific requests, the edition of 1,500 has been almost completely used up. The plan is that this will be revised by the committee during 1949 and published in quantity. Principal committee activity for 1948 was the preparation of an abbreviated, simplified version of the Douglas-fir second-growth manual for the owners and operators of woodlots and small timber tracts. This is in process of revision and the plan is to complete and publish this cooperatively during 1949. Results of 1947 post-mortem survey of some twenty typical second-growth areas were compiled and analyzed during 1948. Findings are to be issued in multilith in 1949.

Pine Management

Evidence is gradually accumulating in favor of light selection cutting as the most effective initial step that can be taken in the conversion of virgin ponderosa pine forests to a condition of net growth. The experience at Pringle Falls, summarized in Research Note No. 45, shows that cuts as light as 20 percent of the total stand may reduce tree mortality to only one-sixth of that occurring in the uncut stand. Similar tests in areas of higher pine beetle hazard on Weyerhaeuser lands in the Klamath Basin and on Black's Mountain Experimental Forest in northern California have met with comparable success. A 17-million-foot timber sale, largest to date on this basis, was laid out and negotiated by the Deschutes National Forest this year.

The recognition of key characteristics that indicate high risk or declining vigor of pine trees is essential for successful results from such light cuttings. In a field conference of entomologists and foresters

held at Seneca, Oregon, last summer it was brought out that experience tests over the past decade have demonstrated the utility of the Keen tree classification and the Salmon-Bongberg risk rating. These classifications are the basis of most pine marking rules in use throughout the region. They have been adopted and checked in growth studies by the Experiment Station.

Recent fundamental studies by the entomologists found that trees rated as "high risk" had an emergence ratio of 1 to 8, i.e., 8 bark beetles emerging for each 1 attacking. In contrast, "low risk" trees had a ratio of 8 to 1, or 1 beetle emerging for each 8 attacking. This indicates why 1 high-risk tree in a group or stand may serve as a focal point for a local insect infestation. Problems of pine forest administrators, the research programs of the Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine, and the Experiment Station were reviewed and steps taken toward integrating work under way. In cooperation with the Deschutes National Forest a commercial-scale test of intermediate harvest cuttings was laid out in dense, high-yield, 104-year-old ponderosa pine second growth at Pringle Falls. The objective is to perpetuate the current rate of growth, now above 500 board feet per acre per year on parts of the area, and to forestall accumulating insect mortality. The plan is to complete sale negotiation and make the cut in 1949.

With the reactivation of John Day Experimental Forest and Range (formerly Blue Mountain), first steps were taken in a comprehensive study of management of the pine and Douglas-fir, white fir, larch types for dual use--timber and range. In cooperation with the Whitman National Forest, preliminary timber sale layout was made for testing (1) sanitation-salvage cutting, (2) current regional marking practice, (3) very heavy selection cutting--leaving a minimum to meet State law requirements, (4) follow-up stand improvement and planting to favor ponderosa pine and to favor the best trees of other species, and (5) small-area clear-cuts with conversion to selected range grasses. Cuttings, dependent upon a new access road through the area, are scheduled to begin in 1950.

The growth possibilities of lodgepole pine were clarified in a post-mortem study of partial cuttings of this species on the Deschutes-Klamath Plateau. Gross growth rates of stands left after logging for cross ties a decade or so ago were from 62 to 101 board feet per acre per year. However, heavy losses of unhealthy trees that should have been cut reduced net increment to only 39 to 83 board feet. Contrary to general impressions, most stands were found to be unevenaged and apparently adapted to a flexible selection system of cutting. The growth-predicting scheme and the crown-vigor classification devised by the Rocky Mountain Experiment Station were tested and found to be fairly applicable. They should be useful for making growth estimates and as an aid in timber marking until more precise local data are obtained. Although demand for lodgepole pine for power poles and common lumber has slackened with recent decline in the market for these products, there is accumulating interest in the species by pulp and fiberboard manufacturers.

Applied Forest Management

The usefulness of silvicultural principles, regardless of how biologically sound they may be, depends directly upon the technical skill and ingenuity of the foresters and logging engineers who must apply them within physical limitations of accessibility and topography--within the economic limitations of utilization facilities and markets. Practical problems encountered in planning road and logging layouts for wild watersheds being organized for sustained-yield management cannot be solved by small-plot research. They must be solved by on-the-ground study and coordination of silvicultural and engineering objectives in commercial-scale operations.

Thus, the major share of the Division's effort is in the field of applied forest management. The Sections of Silviculture, Fire Studies, and Mensuration determine technical objectives to be sought in experimental cuttings. The Section of Applied Forest Management has responsibility for solving the on-the-ground problems encountered in seeking those objectives and coordinating them with economic objectives. This is the plan of operation being followed in all of the cutting experiments in Douglas-fir second growth, old growth, in spruce hemlock, and in pine, described in the sections above.

Research investment is being made in the effort to have authoritative answers ready to guide future management. In addition, applied cutting experiments under way at Cascade Head since 1947 and at Henderson Creek starting in 1948 have already contributed new ideas that have found use in everyday forest management jobs, both on and off the national forests. Some of these are described in Research Note No. 42, "Advantages of a Detailed Pre-Sale Layout and Logging Plan," issued during the year, and also in "Getting Forestry into the Logging Plan." The latter report will be published in a local trade journal early in 1949. Promising findings are being incorporated into experimental cutting plans for further test. For example, it was found at Cascade Head that windthrow around the margin of staggered settings consists almost entirely of trees falling into the remaining stand rather than out into the clear-cut openings. Most of the damage was caused by southwesterly winds. Thus, future cuttings are being laid out to expose as little as possible of the new timber edge to winds from this direction. Areas previously heavily sheltered have been found to be especially susceptible to wind damage following new exposure by cutting. In the partial-cutting tests in progress at Cascade Head skidding with horses is proving to be a more efficient method of operation than was anticipated. Moreover, the horses are doing far less damage to the remaining trees than are the tractors operating on a comparable setting in the same stand.

Foresters supervising thinnings and partial cuttings recognize the need for laying out skid roads before falling begins. The procedure is then to "fall to the lead" in order to facilitate skidding and to minimize damage to the reserve stand. At Henderson Creek it has been found desirable to go still further and to lay out skid trails even before

trees are marked for cutting. Since it is necessary to cut some trees in the construction of skidways, the timber marker should know which trees are to be so removed if he is to do a skillful job of marking adjacent timber. At Cascade Head has developed an hypothesis for facilitating the regeneration of brushy areas during logging. Usual practice in the layout of staggered settings was to log just to the margin of such brush patches, leaving them undisturbed as a part of the delayed setting. At Cascade Head, however, when brushy areas occur near a setting margin the cutting line is placed in the timber beyond the brush patch when possible. Then, during the logging, tops are felled into the brush and logs skidded through it in order to facilitate further destruction of the brush during the slash burn.

The Section of Applied Forest Management is working closely with regional and national forest personnel in the development and testing of timber-survey techniques designed to provide the stand and terrain information essential to preparation of sustained-yield management plans and skillful layout of roads and logging. The combination of aerial photo analysis and new ground sampling techniques gives promise of reducing costs and speeding the work substantially without sacrifice of needed accuracy.

Regeneration - Natural or Artificial?

Almost 6 million acres of cut-over and burned forest land in the Pacific Northwest Region has been rated as non or poorly stocked. A considerable but unknown proportion of this area must be planted if productivity is to be restored. Impressed with the magnitude of this problem, both private and public agencies continued through 1948 to expand their artificial regeneration programs.

To speed this work and, if possible, to reduce costs, experimentation in techniques of direct seeding has been revived. Tests made by the Forest Service extending back to 1911, though successful in some instances, were generally undependable. Now, using new procedures for poisoning seed-eating rodents and employing airplanes and helicopters for disseminating the seed, the State of Oregon, Crown Zellerbach Corporation, and Weyerhaeuser Timber Company are making extensive new tests of direct seeding. The Station cooperated in the planning phases of this work. Our principal effort in direct seeding, however, has been in the development by Isaac and Silen, working with the Forest Service Equipment Laboratory, of a light hand seeder that will quickly plant at a selected depth one pelleted seed at a time. During the year important mechanical improvements were made in the planter. Silen's experiments at Yale indicated that conventional pelleting processes destroy or inhibit the germinative capacity of the seed, probably by limiting the available oxygen supply. As a result, new type pellets have been developed which, it is believed, will not retard germination. Field tests of the new technique are planned for the Henderson Creek, Cascade Head, and Wind River areas during 1949.

Survey of cutovers in the Puget Sound territory (see Research Note No. 41) and along the Oregon Coast show that mere existence of a reasonably good seed source does not insure prompt, dense regeneration. Some severe southerly and westerly exposures and particularly brushy areas were found to be unsatisfactorily stocked after years to decades of waiting, in spite of nearby seed trees. In an attempt to identify ahead of time severe brush-threat areas and to establish conifer forest promptly, planting experiments are being installed in the applied forest management cuttings at Cascade Head and Henderson Creek. Douglas-fir, Sitka spruce, Port Orford white-cedar, western redcedar, and western hemlock are being included in the trials, as is the study of the effects of slash burning and soil type.

Isaac's manuscript, "Better Douglas-fir Forests From Better Seed," resulting from his cooperative study with the University of Washington, was revised during 1948 and sent to the printers. Emphasizing the values to be gained by skillful selection of seed to be used for reforestation and outlining specific procedures for obtaining seed well adapted to the planting site, the report is to be printed as a University of Washington bulletin.

Munger summarized in an article for the Arboretum Bulletin results of tests of exotics as "The Wind River Arboretum From 1912 to 1947." Among the 135 species of conifers included in the plantings are a number that have made excellent development, though none have outstripped the best of our native trees growing nearby. The arboretum is of much interest to foresters, botanists, and students who visit the experimental forest, and as new species likely to survive become available they will be added to the present collection.

In cooperation with the Deschutes National Forest, five test plantations of ponderosa pine were made last spring to determine effect of wax coating, depth and method of planting, and soil moisture on survival. Age 2-0 stock was used. During the unusually moist first growing season that followed, survival for the untreated stock averaged unusually high, 90 percent, and did not appear to vary significantly with depth or method of planting or with smaller-than-usual differences in soil moisture on the sites tested. However, wax coating apparently did reduce survival somewhat, that for the treated trees averaging 70 percent. Since this result is exactly opposite to that experienced elsewhere with this wax treatment, the experiment will be repeated in 1949 to find and, if possible, correct the cause of losses of the treated stock.

Forest Mensuration

Organization of tree farms and virgin watersheds into operating units occupied an increasing number of technical foresters in the region during 1948. Management plans being prepared, however, are less specific than they should be owing to the need for more accurate methods of predicting future volumes and growth rates for most of our typical forest

stands. Completion of this work is handicapped by the lack of a full-time forest mensurationist on the staff. Progress was made during the year, however, through the employment by the Station of Professor George Barnes of Oregon State College during the summer, through cooperation with the firm of Mason, Bruce and Girard, the Oregon State Forester's staff, the British Columbia Forest Service, and a number of private timberland owners. A small part of Floyd Johnson's time was devoted to mensuration studies through cooperation of the Forest Survey.

Barnes completed the job of revising the western hemlock site index curves with the assistance of Engstrom of the Oregon State Forester's office, devising new analytical techniques to coordinate the data from Alaska, British Columbia, Washington, and Oregon. The new curves follow approximately to age 100 years those previously used, but fall far below in the older age classes. Results will be distributed early in 1949 as Research Note No. 50. Considerable progress was made on computation of the new hemlock yield table. Barnes plans to complete the manuscript on this next summer for publication as a technical bulletin.

Basic computations for regional hemlock taper tables were completed by Engstrom and Johnson during the year. The plan is that the finished tables will be derived and distributed before mid-1949. A red alder volume table project was started during the year in cooperation with the Oregon State Forester and Weyerhaeuser Timber Company. The Willamette Research Center started the job of adjusting the Douglas-fir, Sitka spruce, and western hemlock second-growth volume tables to conform to local practices--utilization to an 8-inch top, scaling by 32-foot logs.

New converting factors for 8-foot Douglas-fir pulpwood were determined by the Puget Sound Research Center with the cooperation of local pulp mills. Preliminary study in 1947 indicated a solid-wood content of 82 cubic feet per cord. Additional measurements, however, show that cubic content may vary from 81 cubic feet per cord for stacks having average stick diameter of 8 inches to 91 cubic feet per cord for piles averaging 20 inches in stick diameter. Likewise, it was found that board-foot contents by Scribner rule ranged from 365 to 650 board feet per cord, depending on stick size. The full report covering hemlock and cottonwood as well as Douglas-fir will be published early in 1949.

A helpful shortcut for the determination of site index for Douglas-fir was also devised during the year by the Puget Sound Center. The conventional method required that average heights and ages of dominant and codominant trees be determined in the approximate proportion in which they exist in the stand. By the new method, site may be determined accurately enough for most purposes merely by measuring total height and counting age of a few more easily visible representative dominants. The resulting average of the height measurements in feet is then reduced by:

$$2.66 + (0.04 \times \text{average height of dominants})$$

The remainder is then used as an estimate of the average height of

dominants and codominants and is referenced against the existing site curves in the usual manner.

In response to requests from foresters preparing management plans for Douglas-fir tracts, the standard regional yield table was adjusted to International $\frac{1}{4}$-inch kerf log rule basis. An advantage of this rule is that log scale by this measure approximates the volume of green lumber recovered by sawmills of average efficiency and cutting a normal mill run of lumber sizes. The International $\frac{1}{4}$-inch kerf rule gives a log scale from 5 to 21 percent greater than does the Scribner, depending on tree size. (See Research Note No. 46.)

The preliminary growth rates by tree class for immature Douglas-fir, computed at the Puget Sound Center last year, were published in the Douglas-fir second-growth handbook. These have been revised and improved and the study extended to cover mortality by tree class so that rates of net increment can be computed. A multilithed report summarizing results of this work is planned for 1949.

Probably the most significant contribution in the field of mensuration during the year is a new and simplified type of yield table for second-growth Douglas-fir. The revised table is based on (1) average tree diameter, (2) number of trees per acre, and (3) average tree height--in contrast to the conventional tables which are based on (1) age and (2) site and for which adjustment must be made in application to any specific stand for (3) stocking class. The new table has the advantage that the variables upon which it is based are easily determined by ground sampling. It is also believed that it will be more readily adaptable to aerial photo survey methods than normal yield tables, because the variables used--number of trees, tree diameter, and tree height--are more readily determinable on photographs than are stand and age site. The new tables are being distributed for field testing in a multilithed report, "A Revised Yield Table for Douglas-Fir," by Donald Bruce of the firm of Mason, Bruce and Girard and Collaborator at the Station.

Fire Studies

Although number of fires and acreage burned have, in general, decreased in Oregon and Washington in recent years owing to greater prevention efforts, better detection and suppression, and absence of the usual long periods of critical fire weather, there are still many unsolved problems in the control and use of fire. Adequate solutions will reduce fire losses and fire control costs and may improve forest regeneration.

Study of the use of fire to reduce the hazard following clear-cutting in the Douglas-fir region had the highest priority during the past year. The fire season of 1948 again emphasized the critical nature of this problem when the largest and most costly fire of the summer in defiance of quick control efforts swept away several thousand acres of unburned slash in one afternoon and night in late June. The weather was

not exceptionally dry before the fire started; if it had been, another burned area comparable in size to the Tillamook Burn might have resulted.

Some of the activities and the findings of the past year are reviewed:

Comparison of summer fuel moisture with that of previous years. Moisture content readings from forest fire fuel moisture indicator sticks located at 55 fire danger rating stations at both high and low elevations on the national forests show that in a large part of the region the summer of 1948 was the most favorable in the period 1941-48. In southern Oregon, however, 1947 was more favorable than 1948. In eastern Oregon, except for the northern Blue Mountains, the 1941 season was more favorable.

Accuracy of fuel moisture indicator sticks measured. Fuel moisture indicator sticks, though the best available index of forest fire fuel moisture changes, are subject to errors caused by weathering losses of the original dry weight of the wood. To determine the significance of these errors, measurements of the rate of loss of dry weight during the fire season were made at experimental forests representing three different summer climates, and on each national forest ranger district in Oregon and Washington. Loss was found to increase with the amount of damp weather in the different parts of the two States. In the coastal belt and the west slope of the northern Cascade Range this resulted in errors of about 15 to 20 percent of the true fuel moisture value for days of moderately dry weather. In the southern Cascades and east of the Cascades the errors were equivalent to about 5 to 10 percent of the true values during moderately dry weather. Correction factors to allow for stick weathering must be used before comparisons of fuel moisture in different climatic zones can be precisely made.

Study of burned and unburned slash plots. Forty additional paired plots, one to be burned and one nearly identical to be left unburned, were carefully selected in clear-cut Douglas-fir slash areas this year. This is the third consecutive season that such plots have been selected to study the effect of slash burning on the rate of conifer, brush, and weed regeneration and growth in different parts of the Douglas-fir region and on different soils, aspects, slopes, etc. Comparative effects should begin to appear when the plots are examined next summer.

Weather effects on slash fires. Use of broadcast fires in the Douglas-fir region to reduce the tremendous hazard of slashings from clear-cutting without injury to surrounding forest, seed trees, or soil requires precise knowledge of how the fire will behave with any given weather, fuel, and topographic conditions. To build up such knowledge, slash fires are being systematically studied at every opportunity. Weather was highly favorable for slash burning in western Oregon during the fall, and basic meteorological and fire behavior data were obtained from the burning of ten tracts.

The results and danger of broadcast burning slash from clear-cutting in the fir region just before an anticipated rain as compared to the first clearing period immediately after rain has sufficiently soaked the duff were analyzed and described in "Slash Burning Following a Rain," published in a local lumber trade journal. For many years most of the burning was done the day a rain was anticipated or was beginning so that later control or mop-up could be avoided. The rain often came at the end of a period in which the duff in both the forest and cut-over areas had become dry, and the fires burned deeply, killed scattered seed trees, and killed or injured adjoining edges of green timber. Oftentimes the rain did not occur or stopped soon after the fires were set. By burning in the calm weather of the first few clear days after a rain when the fine slash has dried but the duff is still moist, some experienced slash burners have achieved much less destructive burns with only slightly more expense for mop-up and with no dependence on anticipated rain.

Plans for future fire studies. Additional fire research funds provided for the fiscal year ending July 1, 1949, will make it possible to intensify and expand work in this section. One additional experienced and technically trained man will join the staff in January and another younger staff man will be added in the spring. Emphasis during 1949 will continue to be on problems of fire in the treatment and protection of recently cut-over land in the Douglas-fir region. An additional phase of this will be to determine the relationship of intensity of forest utilization to slash hazard and study of hazard reduction achieved by burning road-clearing slash. Studies of behavior of wild fires and slash-burning fires needed as the basis for efficient fire control planning will be expanded. Activities which have not been started, but which should be begun when resources become available, are: (1) Study of test fires to speed up the collection of rate of fire-spread data under specific weather, fuel, and topographic conditions; (2) tests of the effect of burning techniques that might be used to control species composition and to thin stagnant regeneration in the ponderosa pine region; (3) tests of effects and burning techniques to remove brush that has taken over numerous areas in the Douglas-fir region.

Forest Soils Studies

The forest soils study project, begun at the Station late in 1946, has now passed through its initial period of program building, has produced some usable results, and has been a factor in building an increasing awareness of the importance of the forest soil in the region. This mounting interest was strongly evidenced in September 1948 when a Committee on Forest Soils of the Douglas-fir Region was formed under the co-sponsorship of the Puget Sound and Columbia River Sections of the Society of American Foresters. The purpose is to serve as a focal point for problems and information on forest soils and to encourage the study of forest soils by all forestry organizations in the region. Isaac and Tarrant represent the Station on the new committee. Further evidence of mounting interest in soils is the increasing number of requests from

administrative technicians encountering soils problems on planting and stand improvement projects.

The program of forest soils research being followed by the Station has three main divisions:

(1) Study of soil and site factors influencing tree growth.

(2) Study of soil and site factors influencing artificial and natural regeneration.

(3) Study of effects of forest management practices on soil.

This is described in a paper, "A Program of Forest Soils Research for the Pacific Northwest," given by Tarrant at the Northwest Scientific Association in December.

The study of soil and site factors influencing tree growth was a major work this year. A manuscript was prepared setting forth the findings of study started in 1947 of Douglas-fir site quality in relation to soil fertility. Briefly, no significant relationship between site quality and available soil nutrients was found in representative undisturbed soils of the Douglas-fir region, thus giving strength to the hypothesis that physical properties of the soil and site are the more important influence on tree growth in this region. On this premise, study was directed toward the physical characteristics of soil and site on the Voight Creek and the McCleary Experimental Forests in the Puget Sound area.

The study of soil and site factors influencing regeneration was continued in the ponderosa pine region of central Oregon. In a test of the effect of summer drought on the survival of seedlings, a series of 1-acre pine plantations was established. They were located to sample climatic conditions from the eastern foot slopes of the Cascades to the more arid conditions of the basalt-underlain soils to the east. Soil-moisture measurements were made at regular intervals throughout the May-October period. Briefly, the observation of total soil moisture made September 3 was the lowest of the season, but in the mountain foot-slope area soil moisture was still fairly high. The 8- to 10-inch soil depth averaged 14.9 percent total moisture while the 20- to 24-inch depth averaged 20.16 percent. This is contrasted with conditions in the more arid pumice zone where, even in this abnormally wet year, moisture dropped to 7.0 percent at the 8- to 10-inch depth and to 7.9 percent at 20 to 24 inches. Accompanying observations of seedling mortality are yet to be analyzed. This study is being continued to obtain measures under more representative dry conditions.

Also designed to give needed information for pine planting in pumice soils is a study of the moisture-holding characteristics of the pumice profile. It has been found in several areas that the moisture-holding capacity of pumice increases markedly with depth, suggesting

that deeper planting to put seedling roots nearer these zones of better moisture supply may aid plantation survival. To test this soil characteristic over a wide area a series of soil samples at successive 6-inch depths was taken for determination of moisture equivalent. Information from this study will be used to guide pine planting so that methods best suited to utilize soil zones of highest moisture-supplying power can be employed.

The study of effects of management practices on soil was begun with measurement of the effects of slash burning upon Douglas-fir soils. Paired plots--one burned the other unburned--were studied and soil samples taken on locations of hard, medium, and lightly burned soil at Wind River and Cascade Head. Determinations of pH and organic matter content are being made and will be successively measured each fall to determine trends of soil changes that occur following slash burning. Additional study plots will be added next year, and measurements of physical soil changes will be made. As a part of this study, Research Note No. 48, "The Role of Organic Matter as a Supplier of Nitrogen in Douglas-fir Soils," was prepared. Analysis shows a very close correlation between total organic matter and total nitrogen in Douglas-fir soils. This suggests the hypothesis that excessively hard slash burning may seriously reduce the supply of nitrogen on which seedlings depend for initial growth. Further studies to test this hypothesis are planned.

RANGE RESEARCH

The Range Research Division set up the following goals to be achieved during 1948:

1. Review and revise the problem analysis for eastern Oregon and complete the problem analysis for central Washington.

2. Complete general plans for grazing studies on the Starkey Experimental Forest and Range with the exception of detailed procedures for sampling vegetation and utilization.

3. Survey administrative seedings on skidroads, landings, and spur roads and prepare guides for future seedings.

4. Prepare brief guides for administrative use describing procedures to use in range reseeding.

5. Complete a manuscript reporting results from the cooperative gopher study for publication as a technical bulletin.

6. Collect the final data on clipping studies started by forests in connection with the big game range study.

7. Continue existing studies on range reseeding, range condition and trend of ponderosa pine ranges, effect of logging on forage production,

and forage utilization under rotation-deferred management at the Starkey Experimental Forest and Range.

Notable progress was made toward achieving these goals even though all were not attained. General plans for grazing studies on the Starkey Experimental Forest and Range were completed and submitted to the Washington Office. The survey of administrative seedings on skidroads, landings, and spur roads and the first rough draft of guides for future use were completed. The first draft on the cooperative gopher-study manuscript was completed, and the planned work on all existing studies carried out.

It was decided that another year's results should be secured before the brief guides presenting procedures for administrative use in range reseeding and the final report on game studies were made.

The transfer of Reid to the Washington Office and the detail of Harris to take the statistical course hindered full attainment of all goals.

Effective Results Secured During 1948

During the 1948 season several valuable results were secured which will be useful in the administration of range lands, or in the planning of future range research studies.

Perennial grasses can be successfully seeded on ground denuded during timber harvest. Seeding to perennial grasses has proven an effective method for stabilizing soil, preventing invasion by undesirable plants, and restoring or increasing forage production. This was found by a survey made in 1948 of 84 areas east of the Cascades seeded between 1940 and 1947. Forty-five percent of the seedings made between 1940 and 1946 were good to very good in success, and 71 percent were medium or better. Seedings made in 1947, even though inspected, were not included in the analysis because they were too immature.

Logging and subsequent slash disposal create bare ground. From surveys of several cutting areas east of the Cascades, it has been estimated that 10 percent of the ground, or more, is completely denuded during the harvest of timber. In view of the 270,000 acres logged over annually, this denuded ground is a major grass reseeding problem.

Seeding the denuded portions of a logging area to perennial grasses can be fairly positive when a few simple guides on where, when, how, and what to seed are followed. The following general guides have been developed from results of the survey and experience.

Nearly all ground in the ponderosa pine zone totally denuded within the previous year by skidding, road construction, or slash disposal can be successfully seeded.

Mixtures are most desirable for seeding. These mixtures made up of from three to four species of perennial grass should be built around

the use of timothy and orchardgrass, the two most consistently successful species. Other species which have proven well adapted and which can be added to the mixture are smooth bromegrass (Manchar strain), Tualatin oatgrass, crested wheatgrass, and Chewings fescue. Species which have shown up well in experimental work but which have not been used in large-scale seedings are intermediate wheatgrass, pubescent wheatgrass, blue wildrye, sheep fescue, and Alta fescue. Seeding should be at the rate of about 8 and not more than 10 pounds per acre, with 1 pound of timothy and 2 pounds of orchardgrass going into the mixture.

Areas skidded in the winter and spring should be seeded in the early spring. Those skidded in the summer and fall should be seeded in the late fall. Broadcasting the seed, using a motorized broadcaster or hand broadcaster is the most effective method for distributing the seed. Coverage of the seed through harrowing or brushing has not proved necessary except on the drier sites. Most of the seedings have been successful without complete protection from grazing. Caution must, however, be used because overgrazing and trampling have ruined several seedings.

Following the preliminary analysis of the results from the survey, it was evident that a more carefully controlled study was needed of procedures to use in seeding areas denuded by logging. Accordingly, a detailed study was begun in the fall of 1948 on the Umatilla and Ochoco National Forests of eastern Oregon and on the Colville Indian Reservation in eastern Washington. This study provides a test of thirteen different species of grass in pure stands, seeded at three different seasons and under two conditions of grazing.

Pelletized crested wheatgrass seed does not have any advantage over unpelletized seed. Neither pelletized nor unpelletized seed when broadcast on the surface of cultivated or uncultivated sagebrush range are satisfactory methods of seeding. These were the preliminary results from a study established in the fall of 1947 in eastern Oregon on sagebrush range.

In this study, pelletized and unpelletized seed secured from the Bureau of Land Management airplane seeding project near Gooding, Idaho, were tested on range that had been cultivated to eliminate cheatgrass competition and on uncultivated range. Crested wheatgrass was seeded on 1/4-acre plots using the following methods: pellets broadcast at the rate of 43 pounds per acre (2 pounds of seed); unpelletized seed broadcast at the rate of 2 pounds per acre; unpelletized seed drilled at the rate of 2 pounds per acre; and using seed from another lot drilled at the rate of 7 pounds per acre.

Counts made of the number of crested wheatgrass seedlings during the summer of 1948 show no significant difference in results obtained through broadcasting pelletized and unpelletized seed. Using a basis of one mature plant desired per square foot, neither method gave a satisfactory number of seedlings. Drilling at the rate of 2 pounds of seed per acre gave ten times as many seedlings per square foot as broadcast

pelletized seed. Even so, there are only about half as many seedlings as desired to insure a satisfactory mature stand.

Average Number of Crested Wheatgrass Seedlings Per Square Foot

Method of seeding	Cultivated area	Uncultivated area
Seed broadcast at rate of 2 pounds per acre	0.32	0.08
Pelletized seed broadcast	0.10	0.05
Seed drilled at rate of 2 pounds per acre	1.02	0.85
Seed drilled at rate of 7 pounds per acre	4.62	4.05

Laboratory tests on the pelletized and unpelletized seed showed clearly that the process of pelletizing reduced the viability of the seed. Part of the reduction of 55 percent in viability may have been the result of an excessive amount of damage to the seed in the pelletizing process and part of it to other factors.

Timely use of fire reduces cheatgrass competition. Marked reductions in numbers of cheatgrass plants were secured where cheatgrass was burned in the previous year shortly after maturity. In view of these results, use of fire holds promise as a method of reducing competition preparatory to reseeding to perennial grasses. The results from a study in central Washington, shown in the table below, follow pretty much the same pattern found in southern Idaho. Plowing was the most effective method for thinning cheatgrass, but burning in July may be effective in reducing the numbers of cheatgrass plants the following year to from 10 to 20 percent of the number on an undisturbed stand. Records taken in 1947 and 1948 on the areas burned in 1946 show that the reduction resulting from July burning is effective only during the first year after burning. By the second year the competition is again keen. It is clear that seeded species must become firmly established the first year after burning is used as a treatment. Plowing gives more lasting relief from competition than burning.

Average Number of Cheatgrass Plants Per Square Foot
in Different Treatments of Cheatgrass Eradication Study

Treatment	Treated in 1946		Treated in 1947
	Numbers in 1947	Numbers in 1948	Numbers in 1948
No treatment	124	91	109
Burned in October	70	80	74
Burned in August	44	110	21
Burned in July	10	66	20
Plowed	2	21	19

Double-sampling and sub-sampling found useful in range studies. These were the conclusions from two sampling studies, conducted in connection with the design of experimental studies for the Starkey Experimental Forest and Range.

The first of these sampling studies had to do with the use of double-sampling as a means of reducing the time and expense or increasing the efficiency in a study of seasonal yield of two or three of the main forage species. The current herbage production of bluebunch wheatgrass was harvested at two different dates on eight plots, and of elk-sedge on one date on four plots. Weights of herbage were estimated just before harvest. From these data, it was found that double sampling could be very profitably employed in a study of seasonal yield. It was also found that the optimum ratio of clipped plots to estimated plots, on the basis of the relationship between estimate and actual and the relative cost of using the two methods, would be 1:5.

The second sampling study was conducted to determine the value of sub-sampling for use in forage inventory and forage utilization work on experimental pastures. Open grassland, open ponderosa pine, and dense timber are the three broad range types occupying the pastures. The objective is to measure the change in herbage production, utilization and trend in condition within the types in each pasture. With this objective, the sampling study sought to determine the number of plots per cluster, and the number of clusters of plots which would need to be located at random within the type to adequately sample the changes occurring within the types as the result of different intensities of stocking and different systems of grazing. As would be expected, the number of plots per cluster and the number of clusters needed varied inversely to the abundance and uniformity of distribution of the species. Using this relative variation and the relative amount of travel (relative cost) between and within clusters, the best number of plots per cluster was found to be 5 for open grassland, 3 for open timber, and 3 for dense timber.

Such tremendous variation was found in the abundance of different plant species between clusters that almost a prohibitive number of clusters would be required to sample adequately the abundance of all the major species in any one of the types. For example, with 5 plots per cluster in the grassland type, only Sandberg's bluegrass would have a sampling error of less than 10 percent (8.2) if 25 clusters were taken. One-spike Danthonia would have a sampling error of 15 percent and the sampling errors of all other major species would range from 20 to 60 percent. However, when considering the abundance of all species in the type, a sampling error of 4 percent for total volume was obtained with the same sampling intensity. This means that although the abundance of individual species cannot be sampled adequately, we can sample adequately the total volume which is made up predominantly of grass in this type. Through the use of permanent plots we have every reason to expect less variation in change than was encountered in the abundance and it seems very likely that change can be adequately sampled for the major species.

The "Moosehorn" found valuable for measuring crown-spread of tree overstory. The Canadians developed an instrument they called the "Moosehorn" for use in measuring crown density. This instrument was tested in connection with studies of effect of logging on forage production. Some modification in design has been necessary, but with these modifications the "Moosehorn" has been found to be a very useful instrument for securing impersonal and fairly reliable estimates of tree overstory.

The intensity of sampling needed was tested in the open-timber type of the study area used in the study of sub-sampling. The analysis indicated that a sampling error of 10 percent could be secured with 9 readings per cluster and 20 clusters. Such an intensity of sampling on a 320-acre area would take roughly $1\frac{1}{2}$ man-days time for field work.

A full-scale demonstration of various pieces of sagebrush removal equipment in operation held at Valley Falls, Oregon, is worthy of note not because it presented new results but because of the widespread dissemination of results already at hand. Moreover, this demonstration, which had an audience of over 400 people, was the kickoff to a 5-year range reseeding contest being sponsored by the Rotary Club in Lake County. The publicity secured and the enthusiasm aroused regarding the subject of sagebrush removal and range reseeding were without parallel.

This demonstration, sponsored by the Rotary Club, and participated in by many civic and trade organizations, Federal, and State agencies, in addition to the Forest Service, was an outstanding example of community and cooperative effort in education in range improvement.

Several Manuscripts for Publication Begun in 1948

The first rough drafts of several manuscripts were completed during 1948. These manuscripts, with their prospective avenue of publication, are as follows:

1. A cooperative report with the Fish and Wildlife Service dealing with the life history and effect of pocket gophers on depleted mountain meadows is for publication as a technical bulletin either by the Department of Agriculture or Department of Interior.

2. Results from range reseeding trials with pelletized grass seed is intended for release as a mimeographed station research note.

3. A manuscript presenting guides to seeding perennial grasses on skidroads, landings, and spur roads is intended for preliminary release as a mimeographed station research note.

4. A manuscript reporting comparison of Meeks' Table and Devil's Table is intended for publication in one of the professional journals.

5. A manuscript reporting the adaptation of the "Moosehorn" to the measurement of crown densities of trees is intended for publication in one of the technical journals.

All of these manuscripts, except that on the effect of gophers, are to be completed in final form and submitted for publication during 1949.

Plans for 1949

Plans for 1949 call for the continuation of all existing studies. Final data will be collected on the clipping study of game forages. The first rough draft of the problem analysis for central Washington and the final draft of that for eastern Oregon are to be completed.

Construction of one set of six pastures on the Starkey Experimental Forest and Range is to be completed as soon as weather will permit and the other set of six pastures is to be constructed during the early fall. Headquarters development at the Starkey area will continue.

Manuscripts for publication which will be completed in at least first rough-draft form during 1949 are as follows: (1) A reseeding manual for range lands within and adjacent to the forests of eastern Oregon and Washington, to be prepared in cooperation with the Division of Wildlife and Range Management; (2) a report on the immediate effects of logging on forage production; and (3) a report on the results from the sampling studies conducted during 1947 and 1948 on the Starkey Experimental Forest and Range.

Plans for activating the John Day Experimental Forest and Range during 1949 (formerly called Blue Mountain) call for cooperation by range research in the studies of different methods of timber harvest. The effects of cutting timber on several blocks in the experimental area according to different intensities and to different marking rules will be evaluated from the standpoint of range forage as well as from the standpoint of timber production.

FOREST INSECT INVESTIGATIONS

(Bureau of Entomology & Plant Quarantine
in cooperation with Forest Service)

Studies of forest insects and their control are conducted throughout the country by the Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine. These studies are undertaken cooperatively with the Forest Service, other Federal and State agencies, and private timber owners. The area covered by the Portland Forest Insect Laboratory is coincident with Region 6 of the Forest Service.

Forest Insect Situation in 1948

Surveys to locate and evaluate insect outbreaks and to provide basic data for control have been conducted annually for over thirty years in the ponderosa pine stands of Oregon. Forest insect surveys in other parts of Oregon and Washington, particularly in the west side forests, are of much more recent origin. The survey of 1948, the most comprehensive to date, disclosed a generally favorable situation, except for an outbreak of the spruce budworm which threatens to get wholly out of hand.

Losses caused by the western pine beetle were at a low endemic rate on all areas in 1948. This is a continuation of the favorable loss pattern of recent years. No direct control against this beetle will be necessary in 1949.

The mountain pine beetle was locally aggressive in scattered white pine stands of the Washington Cascades. The affected timber was generally inaccessible and of submerchantable size, thus making control impractical, except in Mt. Rainier National Park where scenic values were involved. A potentially serious outbreak of the mountain pine beetle in lodgepole pine in and adjacent to Crater Lake National Park was successfully suppressed through joint action by the Forest Service and the Park Service in 1947 and 1948.

Losses caused by the Douglas-fir beetle continued generally low. This beetle, against which no practical control measures have yet been devised, was most active in southern Oregon. In the Blue Mountains it flared up locally in trees that were partially defoliated in 1946 and 1947 by the Douglas-fir tussock moth.

The Douglas-fir tussock moth, which was widely epidemic in 1947 in the Blue Mountains and in northern Washington, subsided to normal in 1948. Part of the control is attributed to aerial spraying in 1947 and part to insect parasites and a polyhedral virus disease.

Two small outbreaks of the hemlock looper on the Olympic Peninsula subsided in 1948 after having killed an estimated 3 to 5 million board feet of hemlock during the preceding two or three years.

The spruce budworm, a major enemy of fir and spruce forests in much of North America, has been steadily building up in the Pacific Northwest since 1943. The recorded extent of infestation increased from 1,000,000 acres in 1947 to 1,446,000 acres in 1948. West side Douglas-fir stands became involved in the outbreak in 1948 when a 120,000-acre center of infestation showed up near Eugene, Oregon. In the fall of 1948 a representative committee of public and private foresters developed a plan for controlling the budworm in the Pacific Northwest. The first phase of this plan calls for the aerial spraying in 1949 of approximately 200,000 acres in two blocks in Oregon.

The Spruce Budworm and Its Control

Over a period of many years much effort has been spent in the United States and Canada to develop effective measures for combatting the spruce budworm. Several promising leads have been uncovered, but through 1947 there still was no fully tested method available for practical control. Because of the urgent need for proven control measures, plans were made for large-scale tests in 1948 in Oregon.

The tests were made in late June and early July on the Umatilla National Forest through the cooperative efforts of the Forest Service, Oregon State Board of Forestry, Bureau of Entomology and Plant Quarantine, and the Kinzua Pine Mills Company. DDT in oil solution was applied in varying dosages by airplane and helicopter to twelve 350-acre plots. The results were highly successful. One pound of DDT in one gallon of oil applied either by airplane or helicopter gave upward of 95 percent control at an actual average cost of $2.17 per acre for materials and spraying. It was estimated that on large practical operations costs would be between $1.50 and $2.00 per acre. This experiment is the basis upon which extensive control is planned both in Oregon and in Maine in 1949.

Pine Beetle Control Through Management Practices

Much work has been done to control pine beetles indirectly by utilizing susceptible trees before they are killed by the beetles. This work has been along three major lines: (1) The recognition and removal of susceptible classes of trees, as defined by the Keen Classification; (2) the recognition and removal of susceptible individual trees--California risk rating; and (3) the recognition and early logging of stands especially subject to beetle attack--area hazard zonation. All three of these concepts have been widely incorporated into management practice in Oregon and Washington.

In 1948 progress was continued on both public and private lands in the application of indirect control through light cuts directed toward the removal of beetle-susceptible trees on hazardous areas. The testing of the basic theories of this method of control was continued on a large series of 160 and 320-acre plots on representative areas. Fifteen additional plots were established in 1948, thus practically completing the scheduled plot layout for this long-term study.

Improving Forest Insect Surveys

Although ground methods still are the backbone of forest insect surveys, aerial methods of detecting and evaluating insect outbreaks are being increasingly used. The need for rapid coverage of large areas at low cost favors the use of airplanes. There are, however, numerous techniques that must be worked out before aerial surveys are fully perfected.

In 1947 a project was undertaken to evaluate and develop methods for making aerial forest insect surveys. This study was expanded in 1948. It is along three major lines: (1) sketch mapping, (2) strip counting, and (3) photographing.

Aerial sketch mapping can be adapted to plotting insect outbreaks in much the same way that it is used for forest type mapping. In a large-scale practical test of this method some 7,750,000 acres of forested land were covered in 1947 and 780,000 acres of defoliator infestation plotted. In 1948 a total of 11,870,000 timbered acres were flown and 1,446,000 acres of infestation plotted. Costs for flying were a small fraction of one cent per acre. Aerial sketch mapping for detecting and defining forest insect outbreaks has been proven highly practical, but many refinements remain to be worked out.

Aerial strip counting of insect-killed trees is patterned after strip cruising on the ground. Techniques are still in the formative stages and the accuracy of the method remains to be fully determined. Investigations along these lines were conducted in 1948. The method, although promising, has not yet become practical.

Aerial photography is a well established procedure for general forest inventory work, but so far has been used hardly at all for forest insect surveys. Preliminary studies in 1947 and 1948 showed that this method is potentially useful for recording and measuring insect outbreaks. Progress on this phase of the project has been hampered to date by inadequate airplane and camera equipment. More suitable equipment is expected in 1949.

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PERSONNEL

ADMINISTRATION

J. Alfred Hall	Director
Samuel E. Kistler	Administrative Assistant
Stanley A. Norton (5+ mo.)	Chief Clerk
Daniel W. Richmond (5+ mo.)	Chief Clerk
Frances Elliott	Secretary
Erna J. Jeppesen	Library Assistant
Elsie Andrews	Library Assistant
Leah Wheeler	Clerk-Typist
Robin A. Hill (6+ mo.)	Misc. Dup. Mach. Operator
George I. Hall (2+ mo.)	Misc. Dup. Mach. Operator
Edgel C. Skinner (6 mo.)	Statistical Clerk

Temporary

Hazel A. Enney (1 mo.)	Clerk-Typist
Helen Sherman (1 mo.)	Clerk-Typist
Mabel E. Eckersley (3+ mo.)	Clerk

FOREST ECONOMICS

Robert W. Cowlin	Forest Economist
A. Kathryn Flaherty	Draftsman
Emma G. Johnson (7 mo.)	Clerk-Stenographer
Elsa E. Wasser (5 mo.)	Clerk-Stenographer
Marion E. Anderson (8+ mo.)	Statistical Clerk

Forest Survey Inventory

Richard C. Wilson	Forest Economist
Floyd A. Johnson	Forester (Mensuration)
Carl E. Mayer	Forester
Walter R. Johnson	Forester
Robert B. Pope	Forester
Charles E. Tyler	Forester
Willard H. Carmean (8 mo.)	Forester

Temporary

Murl W. Storm (2 mo.)	Forestry Aid (Research)
Stanley E. Spurgeon (2 mo.)	Forestry Aid (Research)

Forest Resource Analysis

Floyd L. Moravets	Forest Economist

Forest Industry Analysis

Sinclair A. Wilson (9+ mo.)	Forest Economist

FOREST UTILIZATION SERVICE

Edward G. Locke	Technologist
Archibald C. Knauss	Technologist
Vivian B. Heigh	Clerk-Stenographer

RANGE INVESTIGATIONS

Joseph F. Pechanec	Forest Ecologist
Robert S. Rummell	Range Conservationist (Research)
May W. Van Staaveren (8+ mo.)	Clerk-Stenographer
Christina M. McPhail (4 mo.)	Clerk-Stenographer

FOREST MANAGEMENT RESEARCH

Philip A. Briegleb	Silviculturist
Robert F. Tarrant	Soil Scientist (Forestry)
Leona M. Bates	Clerk-Stenographer
Emma G. Johnson (5 mo.)	Clerk-Stenographer
Ethel T. Arthur (7 mo.)	Clerk-Stenographer

Silviculture

Leo A. Isaac	Silviculturist

Applied Forest Management

Elmer E. Matson	Forester

Forest Protection

William G. Morris	Forester

Forest Management Research Experimental Forests

Pringle Falls Experimental Forest - LaPine, Oreg.

Edwin L. Mowat	Forester
Walter G. Dahms	Forester

Temporary

Lachlan Macleay (2+ mo.)	Forestry Aid (Research)
Roger E. O'Neal (3 mo.)	Forestry Aid (Research)

Wind River Experimental Forest - Carson, Wash.

W. E. Bullard	Forester
Robert W. Steele (8 mo.)	Forester
William I. Stein (3+ mo.)	Forester

Temporary

Orwin V. Thomas (3 mo.)	Forestry Aid (Research)

RESEARCH CENTERS

Puget Sound Research Center - Olympia, Wash.

Norman P. Worthington	Forester
George R. Staebler	Forester (Silviculture)
Elmer W. Shaw (2 mo.)	Forester (For. Mgmt.)
Melvin P. Twerdal (9+ mo.)	Forester
Ruth L. Kellum (7 mo.)	Clerk-Stenographer
Ruth H. Campbell (4+ mo.)	Clerk-Stenographer

Temporary

Allen M. Fisher (1 mo.)	Forestry Aid (Research)
Lowell F. McDonald (2 mo.)	Forestry Aid (Research)
Charles A. Schwab (3 mo.)	Forestry Aid (Research)
Cale O. Frost (3 mo.)	Forestry Aid (Research)

Willamette Research Center - Corvallis, Oreg.

Robert Aufderheide	Forester
Harold A. Rapraeger	Silviculturist
Roy R. Silen (6 mo.)	Forester (For. Mgmt.)
Nadine G. Verhagen (5+ mo.)	Clerk-Stenographer
Margaret E. Anderson (6+ mo.)	Clerk-Stenographer

Cascade Head Experimental Forest - Otis, Oreg.

Robert H. Ruth	Forester

Temporary

Clarence W. Jacobs (3 mo.)	Forestry Aid (Research)
Kenneth Simpson (7 mo.)	Forestry Aid (Research)
J. E. Wylie (3 mo.)	Forestry Aid (Research)
Edward L. Sullivan (3 mo.)	Forestry Aid (Research)

Siskiyou-Cascade Research Center - Roseburg, Oreg.

Edward S. Kotok (5 mo.)	Forester
Mary H. Winn (4+ mo.)	Clerk-Stenographer

Port Orford Cedar Experimental Forest - Powers, Oreg.

George A. James	Forester (Research)

Blue Mountain Research Center - La Grande, Oreg.

Elbert H. Reid (8 mo.)	Forester
George A. Garrison	Forest Ecologist
Robert W. Harris	Forest Ecologist
Ellerslie W. Stevenson	Forest Ecologist
W. Joan Eales	Clerk-Stenographer

John Day Experimental Forest - Unity, Oreg.

Starkey Experimental Range - La Grande, Oreg.

Temporary

Rex S. ZoBell (3 mo.)	Forestry Aid (Research)
Joe E. Adam (3 mo.)	Forestry Aid (Research)
John W. Bohning (2 mo.)	Forestry Aid (Research)

COOPERATING AGENCY

FOREST INSECT INVESTIGATIONS

Robert L. Furniss	Entomologist
John M. Whiteside	Entomologist
William K. Coulter	Entomologist
John F. Wear	Pilot
Walter J. Buckhorn	Scientific Aid
Kenneth H. Wright	Scientific Aid
Olga M. Wulff	Clerk-Stenographer

Temporary

Bernard C. Brungard (3 mo.)	Scientific Aid